Energy Research and Development Division

FINAL REPORT

Biodico's Zero Net Energy Farm

Energy Self-Sufficiency Using On-Site Renewable Resources in a Disadvantaged Community in the San Joaquin Valley

California Energy Commission

Gavin Newsom., Governor

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PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solution, foster regional innovation and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities – Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company – were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

This *Master Community Design* is a deliverable for the Zero Net Energy Farm project (Contract Number EPC-15-071), conducted by Biodico. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

ABSTRACT

California has pioneered and instituted several policies in the energy sector to address climate change while preserving the state's people, economy, and resources. Development and deployment of new technologies in clean energy are critical to meet California's clean energy goals; yet implementation must expand on a community scale. This especially is important to low-income and disadvantage areas impacted by poor air quality, pollution, and lack of access to funding to widely incorporate clean and cost saving technologies.

The Zero Net Energy Farm (ZNEF) project received a grant from the California Energy Commission under GFO-15-312 for The EPIC Challenge: Accelerating the Deployment of Advanced Energy Communities, specifically in Group 3: Advanced Energy Community Located in a Disadvantaged Community in Northern California. The ZNEF project goal was to make a farm in a disadvantaged community in the San Joaquin Valley energy self-sufficient using on-site renewable resources. The four elements for determining the feasibility of this project were (1) a resource assessment, (2) a technology review, (3) permitting, and (4) financing. These four elements applied to produce the Master Community Design.

The Master Community Design integrates and aggregates twelve components into a virtual power plant that provides renewable power to the ZNEF and responds to automated dispatch requests from the California Independent System Operator and Pacific Gas and Electric Company. The twelve components chosen for the Master Community Design blend intermittent and on-demand renewable energy technologies that are adapted to be agriculturally appropriate and offset a complex demand equation of total volume of power, time of use, peak demand, and frequency modulation to maximize economic viability.

ZNEF project benefits include: (1) ability to be replicated in California's agricultural community; (2) increased grid efficiency, resiliency, and reliability; (3) enhanced energy security by distributing and localizing energy production; (3) mitigated adverse environmental impacts associated with conventional electricity production by decreasing water consumption, mitigating emissions of greenhouse gases, criteria air pollutants and air toxins, and reducing adverse impacts to human health; and (4) green job creation and economic development in one of the most disadvantaged areas of California.

Keywords: renewable, distributed, energy, reliability, resiliency, aggregation

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EXECUTIVE SUMMARY

Introduction

The energy sector, while critical for supporting safety, economic growth, and quality of life, has significant and harmful impacts when reliance is upon fossil fuels. California has multiple policies and programs intended to promote renewable energy in California and ensure that all Californians, including low-income and disadvantaged communities, benefit from this transition. The state's Renewables Portfolio Standard currently requires that 60 percent of retail electricity sales be served by renewable resources by 2030, and Governor Edmund G. Brown's Executive Order B-55-18 set a goal to achieve carbon net neutrality by 2045. As a result, California is moving away from conventional energy sources such as fossil fuel, nuclear, and large hydroelectric projects, and toward distributed renewable power generation such as photovoltaic (solar), wind and biomass projects.

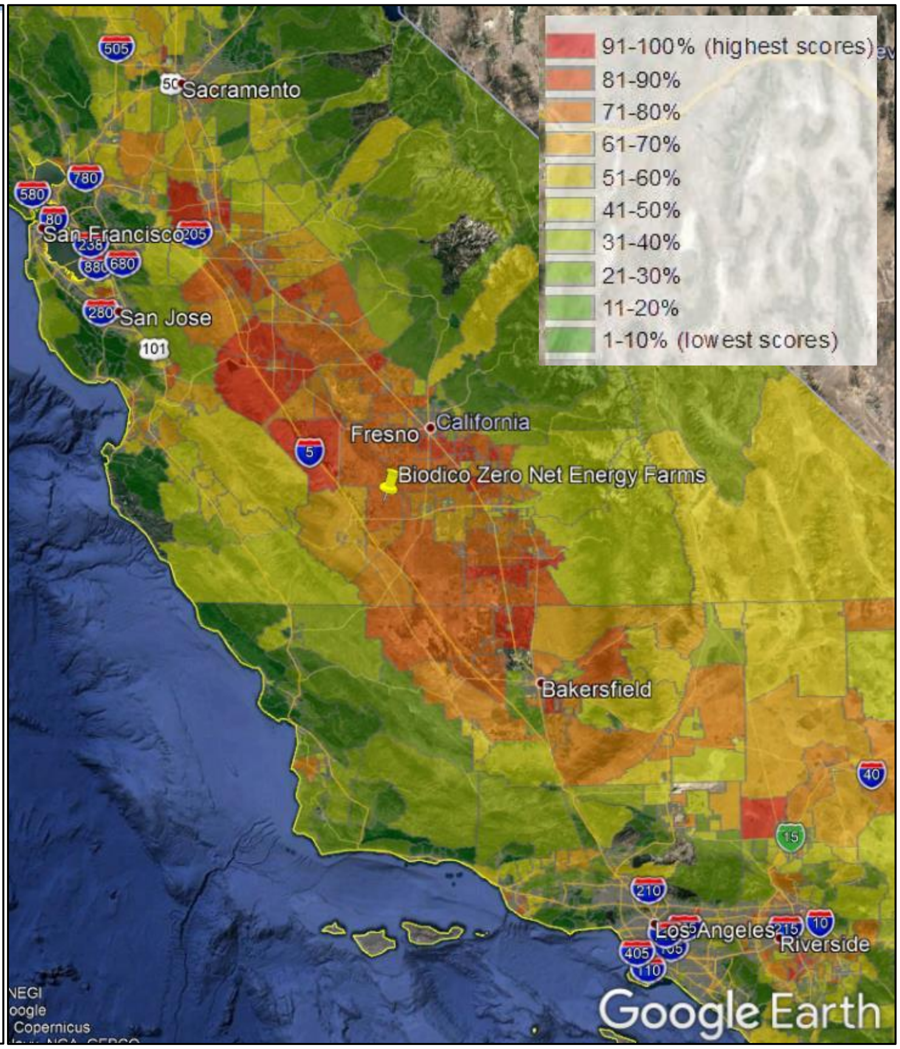
Distributed energy resources (DERs) can significantly reduce the damaging environmental impacts from fossil fuel energy generation, but in turn, create operational challenges for management of the energy generation and delivery system. Balancing power supply and energy demand can be difficult because many renewable power sources are intermittent which can lead to unpredictable and unreliable quality of power. To address these uncertainties, renewable generation sources can be combined with other supporting energy technologies such as energy storage, demand response, and smart power conditioning systems to store excess generation, shift load throughout the day, or aggregate disparate resources to better balance supply and demand. These systems represent a viable path to decarbonize the electric grid, and while there have been early deployments and demonstrations of these technologies, few have been deployed in disadvantaged communities or agricultural or farm settings.

Farms depend on the electricity grid and fossil fuels for everyday operations. These demands continue to increase as new farming technologies are introduced and as ground water use increases. Many farms lack the tools and knowledge necessary to deploy distributed renewable technologies to meet the demands in place of conventional energy systems or increased reliance on the electricity grid. Local governments often prioritize short-term goals to meet the community's needs, but this often becomes a barrier for innovation within the community. Furthermore, farms need guidance to effectively address permitting requirements and find competitive funding alternatives that will allow them to become leaders in California's distributed and renewable energy future.

The goal of the Zero Net Energy Farm project was to create a replicable Master Community Design for a distributed renewable energy project in the San Joaquin Valley, a disadvantaged agricultural community. Disadvantaged communities, defined by the CalEniroScreen3.0 tool as areas at the seventy-fifth percentile or higher, look to benefit the most from an advance energy community model, but frequently lack the necessary funding and resources to develop. Shown in Figure ES-1 is the site of the Zero-Net Energy Farm in the heart of a severely disadvantaged community in the San Joaquin Valley.

Figure ES-1: Location of the Project with CalEnviroScreen 3.0 Overlay

Percentile Range	81-85%
Population	5269
County	Fresno
ZIP	93234
City	Huron
Ozone	0.06
Ozone Pctl	85
PM2.5	13.8
PM 2.5 Pctl	95
Diesel PM	3.98
Diesel PM Pctl	11
DrinkingWater	594.2
DrinkingWater Pctl	64
Pesticides	4848.27
Pesticides Pctl	96
Tox Releases	93.94
Tox Releases Pctl	25
Traffic	166.54
Traffic Pctl	4
Cleanups	2.5
Cleanups Pctl	30
GroundwaterThreats	25
GroundWater Threats Pctl	77
Haz Waste	0
Haz Waste Pctl	0
Imp. Water Bodies	0
Imp. Water Bodies Pctl	0
Solid Waste	1.5
Solid Waste Pctl	39
Pollution Burden Pctl	61
Asthma	61
Asthma Pctl	70
Low Birth Weight	3.61



Source: Map courtesy of Google Earth and CalEnviroScreen 3.0 overlay by the California Environmental Protection Agency

Project Purpose

The purpose of Biodico's Zero Net Energy Farms was to develop a replicable Master Community Design for agricultural properties in disadvantaged communities, with energy self-sufficiency from on-site renewable resources. The project developed and piloted a project management application tool for farm and agricultural communities using Net Energy Meter Aggregation. This tool gathers information from trade studies of available equipment vendors and compares cost effectiveness and reliability of technologies for solar, wind, anaerobic digestion, and gasification. With this tailored combination of technologies for the agricultural areas, Biodico generated a software tool designed expressly for the integration of renewable energy into the IOU electric grids. Zero net energy farms will support energy self-sufficiency, reducing costs, mitigating toxic air contaminants along with criteria and greenhouse gas emissions, and utilizing agricultural waste, wind, and solar to generate electricity. Through the engagement of the agriculture community, comprehensive evaluation, engineering, financial research, and collaboration with local government, Biodico aimed to address the barriers of execution for the agriculture community to transition into zero net energy.

Project Process

Biodico compiled four key elements to create a successful Master Community Design of advance energy communities in the agriculture sector, which were (1) a resource assessment, (2) a technology review, (3) permitting analysis, and (4) financing analysis. Biodico assembled a project team with expertise and experience in each one of these key elements that included entities in local government (City of San Joaquin, County of Fresno, Fresno County Council of Government), community (Red Rock Ranch, Inc., PondelWilkinson, Inc., West Hills Community College District), and the energy sector (San Joaquin Valley Energy Cluster).

First, the project team identified agricultural communities with the prime characteristics needed to result in the greatest benefit, which included:

- Promising renewable resources with sufficient space for necessary hardware,
- Minimal installation of existing advance energy technology established on site, and
- Cohesive ideals between farmers and local government on clean energy goals.

The site location for the project is key to reflect the validity and replicability of the Master Community Design of advance energy communities in the agriculture sector. Biodico chose a 1,300-acre portion of Red Rock Ranch, located in Five Points, Fresno County, California.

First, the project team evaluated the renewable resources available at Red Rock Ranch – primarily solar irradiation, wind and biomass availability. This resource assessment established a baseline for evaluating the potential performance of different distributed energy resource technologies.

Second, the project team evaluated various clean energy technologies and optimized system type, sizing, locations, and potential projected construction. Biodico implemented strategies to utilize the integration of a combination of technologies, while focusing on a reliable and repeatable design process. These strategies targeted a net-zero energy goal while reducing peak demand, lowering costs, supporting cleaner air quality and better utility performance.

Third, the project team worked with the Fresno County on engagement with the agriculture community and local officials. Permitting is often a large hurdle faced by communities looking to adopt cutting-edge clean energy technologies. The project team compiled and analyzed the wants and concerns from farmers and large property owners about the integration of clean energy technologies and then worked with the local city and county government on a permit plan to facilitate the adoption of more clean energy technologies into the community. Ongoing engagement between the project team, community, and local government was vital for transparency in creating the master community design for advance energy communities. Aggregation will allow farmers and large property owners to generate considerable amounts of cost effective and environmentally friendly electricity. Aggregation of meters aims to benefit the renewable energy generators, the IOU's and the local community by allowing distributed generators to increase their ability to integrate renewable energy technologies into the existing grid, increasing energy security and grid stability.

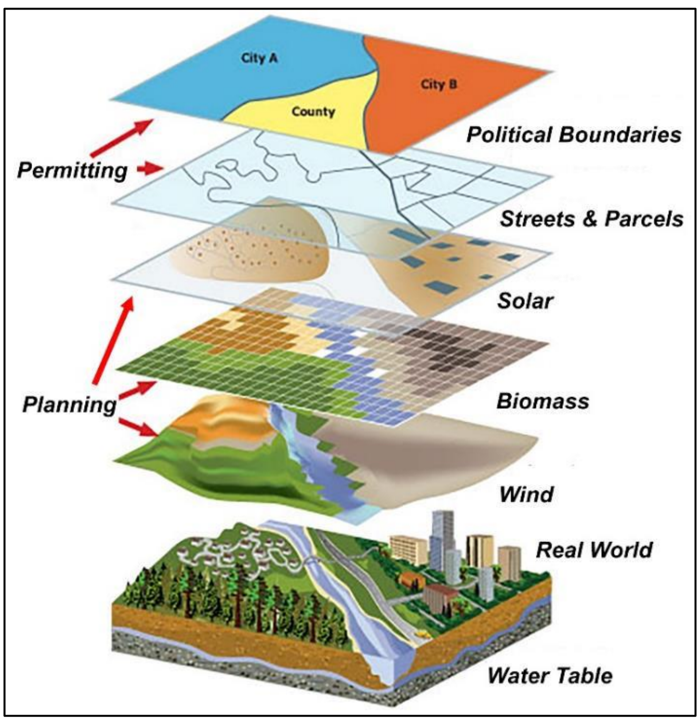
Lastly, the project team created a finance and business model to showcase the innovative financing strategies that can help make the Zero Net Energy Farms financially attractive relative to similar farming developments without advanced renewable energy attributes. Financing is the largest barrier for scale-up clean energy technologies, so with this model, investors and stakeholders can clearly see the value and return in investment of adoption in advance energy communities.

Project Results

The project team synthesized the four key elements mentioned above and created a Project Management Application consisting of an interactive map that layers on disparate data sets and is coupled with a project optimizer (Figure ES-2). This interactive tool, called the Zero-Net Energy Farm (ZNEF) GeoPlanner, is designed for farm owners to assess the renewable energy potential of the property, evaluate a variety of distributed generation technologies, and develop a financing model based on current energy usage, projected energy savings and available incentives. The tool is available here: http://www.zeronetenergyfarms.com/

The project team then piloted the ZNEF GeoPlanner at the Red Rocks Ranch in Five Points, California to create a master community design for a ZNE Farm.

Figure ES-2: Depiction of Interactive Map Layers



Source: Biodico

The Master Community Design includes twelve technology components integrated and aggregated to form a Virtual Power Plant which will be capable of serving renewable power to Red Rocks Ranch and responding to automated dispatch requests from the California Independent System Operator and the Investor Owned Utility for this area, Pacific Gas and Electric. The twelve components chosen for the Master Community Design, including anaerobic digester and smart lamp, are a carefully optimized blend of intermittent and on-demand renewable energy technologies, which are adapted to be agriculturally appropriate and offset a complex demand equation of total volume of power, time of use, peak demand and frequency modulation to maximize economic viability.

The system as a whole has a capacity of 2.149 megawatts and is expected to produce 15,393 megawatt-hours annually. The total cost for the system components and installation is expected to be $15.3 million. The project team determined there are more than $2.4 million of incentives available from the Self-Generation Incentive Program, Business Energy Investment Tax Credit, and the Renewable Energy for America Program, and more than $3.6 million in loan guarantees available from the Renewable Energy for America Program.

Technology/Knowledge Transfer/Market Adoption

The primary users of this research are farm owners looking to adopt clean energy technologies onto their properties as well as local governments looking to increase deployment of clean energy technologies in their jurisdiction. As mentioned, the project developed a Zero-Net Energy Farm GeoPlanner tool which allows farm owners throughout the state to conduct a renewable resource assessment, evaluate a host of distributed energy technologies, and develop a financing plan. The GeoPlanner tool, as well as additional information about the project and its results are available here: http://www.zeronetenergyfarms.com/.

The project featured a technical advisory committee comprised of individuals representing the agricultural, academic, project developer, and local government sectors. Project results were shared with the technical advisory committee at regular intervals during the project term.

The project team also hosted a reception and summit on November 2-3, 2017 which featured a guided tour of Red Rock Ranch and presented the project results and the Master Community Design to interested stakeholders. The event was attended by 96 people representing business leaders, farmers, farmworkers, academics, and local governments.

The project team intends to apply for the Phase II solicitation for advanced energy communities. If this project receives a Phase II award, the project team will begin the build-out of the proposed Master Community Design.

Benefits to California

The benefits of the Zero Net Energy Farm project are that it (1) is highly replicable within California's agricultural community, (2) increases the efficiency, resiliency and reliability of the grid, (3) enhances energy security by distributing and localizing energy production, (3) mitigates the adverse environmental impacts of producing conventional electricity by (i) decreasing water consumption, (ii) mitigating emissions of greenhouse gases, criteria air pollutants and air toxins, and (iii) reducing adverse impacts to human health , and (4) stimulates green job creation and economic development in one of the most disadvantaged areas of California. Roughly $15 billion is spent overall on electricity for California agriculture and 288,000,000 megatons of CO2 are released in California statewide. The first Zero Net Energy Farm project will have many projected benefits related to these two areas. It will save roughly $800,000 in electricity per year for the 1,300 acres of farming and mitigate roughly 4,000 megatons of CO2 equivalent emissions annually. Additionally, the first Zero Net Energy Farm project will save over one thousand acre feet of water and shift roughly 15,000 MWh from peak load times per year. This translates to both cost savings for the farmers themselves and environmental benefits for California as a whole.

Replicability is a primary benefit of this pioneering project. The potential for expansion is derived from the ratio of the acreage for this project to the total cultivated agricultural acreage in California, the US and the world. Assuming 1 percent penetration, the potential quantitative benefits are shown in Table ES-3.

Table ES-3: Replicability Potential of this Master Community Design

Item	ZNEF	CA Ag	US Ag	World Ag
Acres	1,300	25,000,000	915,000,000	3,706,575,000
Ratio	1	19,231	703,846	2,851,212
1% Market Penetration		192	7,038	28,512
MWh/Year	15,393	2,960,127	108,340,654	438,877,331
Annual Cost Savings	$783,887	$150,747,553	$5,517,360,457	$22,350,284,519
Line Loss Recovery (MWh)	831	159,847	5,850,395	23,699,376
Water Reduction (acre ft)	1,181	227,102	8,311,915	33,670,752
TOU Shifting (MWh)	15,392	2,960,043	108,337,561	438,864,804
NOx Reductions (MT)	-7.45	-1,432	-52,424	-212,363
GHG Reductions (MT)	-4,356.12	-837,716	-30,660,405	-124,202,285
Full-time Jobs	18	3,462	126,692	513,218

Source: 2017 Biodico

Aside from electric ratepayers, there are multiple market segments that could greatly be impacted by this project, one of these being feedstock suppliers. Feedstocks for gasification will impact the agricultural market by making use of the otherwise discarded pruning material and solid biomass from nearby orchards and farms. Anaerobic digestion convert waste products from other biomass refineries, trap grease from restaurants, and liquid and slurry waste products from surrounding agricultural and biomass production facilities. Under the assumption that farmers may aggregate electricity-generated onsite and have those rates on hand, the agricultural industry would be greatly impacted by the project. The project will also influence the market for installation, service and operational professionals. Impacted markets are:

- Feedstock providers of woody ag waste
- Feedstock providers of manure (1,800 dairies in CA with over 1,800,000 milking cows)

- Manufacturers of distributed renewable equipment (solar cogen, wind turbines, AD and gasifiers) all of which are manufactured in California.
- Farms, dairies and ranches (reduced utility cost)
- Other agricultural interests (food processors reduced utility cost)
- Consumers (reduced food cost because farmer and processors cost of goods sold is less)
- Labor (increased installation work for the building trades)
- Water market (decreased water consumption for the production of electricity)
- Medical services market (decreased health impacts from lower toxic/criteria air pollutants)

CHAPTER 1: Four Elements – Trade Study Approach, Results and Spreadsheets

The four elements that are necessary to determine if a site is suitable for a distributed renewable energy project are (1) a resource assessment, (2) a technology review, (3) permitting plan, and (4) financing strategy. The approach used in this project was to conduct a trade study for each of these elements and place the results into a spreadsheet so, when appropriate, the essential data could be embedded in an interactive map. The ultimate objective was to create a tool that could be used to plan an optimal Zero Net Energy Farm at Red Rock Ranch; and to develop a tool that can be used by other similarly situated interests.

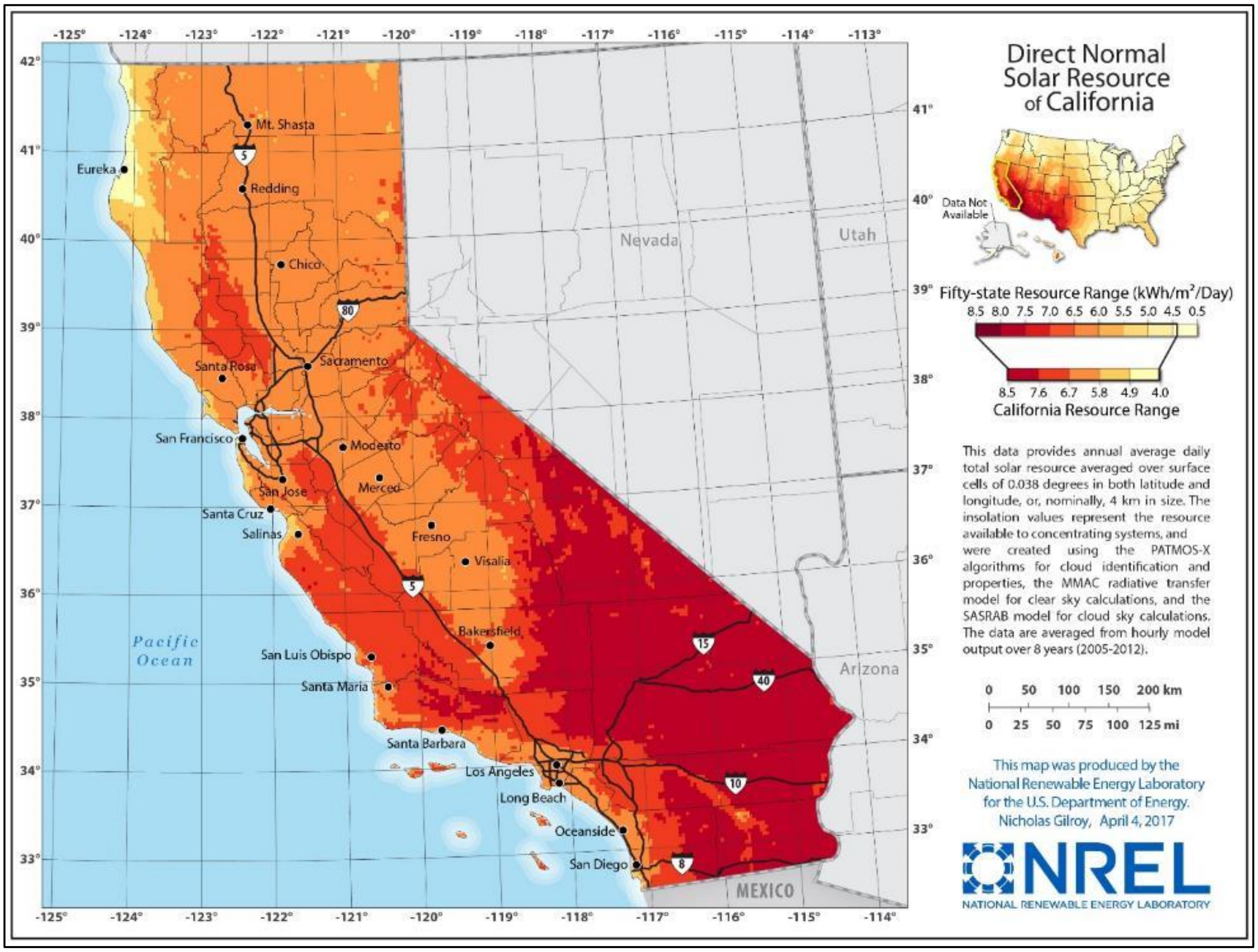
Resource Assessment – Supply and Demand, References

The first step was to determine the adequacy of renewable resources available at a particular site in California for generating renewable power to meet the energy demand for that site. It is a simple supply and demand equation, which determines if there is sufficient renewable energy potential to meet the energy demand at a particular site.

Solar

The National Renewable Energy Laboratory (NREL) under the System Advisory Model publishes the extensive solar data available for California, as the most usable and accurate data. This information is more than just a map; it imbeds all of the data for every day of the year, for every portion of the state down to a 4-kilometer scale. This not only considers theoretical data, based on astronomical prediction, but also the average weather for an area that may impact solar production. For example, the solar data takes into account the number of cloudy days causing shading in a given area combined with increased temperatures from electrical resistance that impact PV production. The basic NREL map, shown in Figure 1, shows the average solar potential for every area of the state. From Figure 1, the direct normal solar resource in the Central Valley Region, where the San Joaquin Valley is located, is 5.8 to 6.7 kilowatt per square meter per day (kWh/m^2/Day).

Figure 1: National Renewable Energy Laboratory Solar Map for California

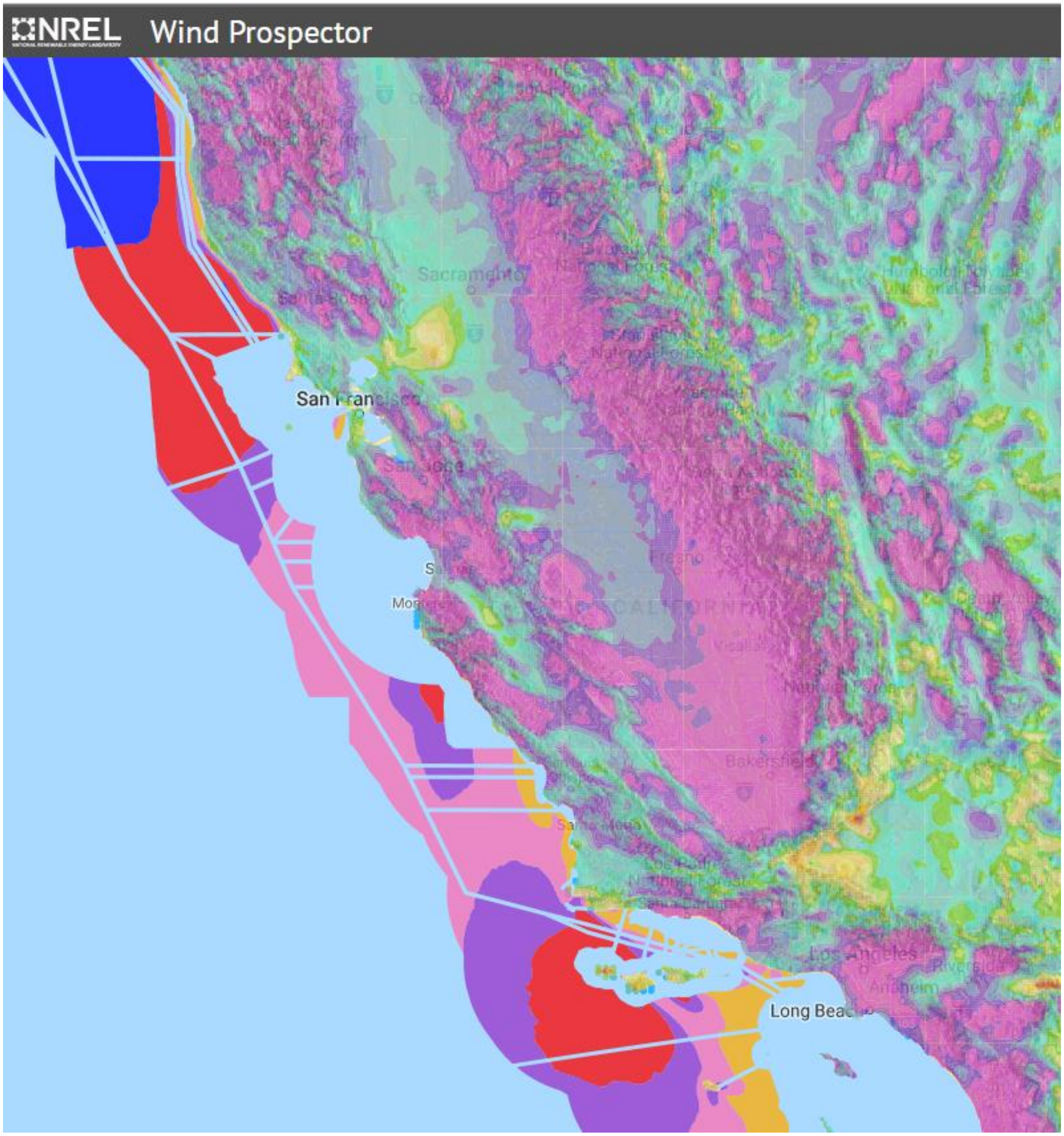


Source: 2018 NREL

Wind

There is extensive wind data available for California published by NREL as the Wind Prospector. This informational map imbeds all of the data for every day of the year, for every portion of the state. However, this data is just a general indication of wind potential at a height of 80 meters, and the Zero Net Energy Farm wind turbines will be at much lower altitudes. Basic surface weather data and wind roses are available for each area of the state with indication of the amount of wind and direction in Figure 2. The Wind Prospector provides multiple factors to consider, but for this project two were considered: hillshade and land-based wind speed. Hillshade represents shaded terrain relief and is valued from range 0 (no illumination, completer shadow) to 255 (full illumination, full sunlight). The land-based wind speed predicts annual wind speeds at an 80-meter height and is valued from 4 meters per second to 10 meters per second. From Figure 2, the Central Valley region, where San Joaquin Valley is located, is a mixture of hillshade with illumination around 180 and land-based wind speed at 80m between 4 meters per second to 5 meters per second.

Figure 2: National Renewable Energy Laboratory Wind Prospector Map

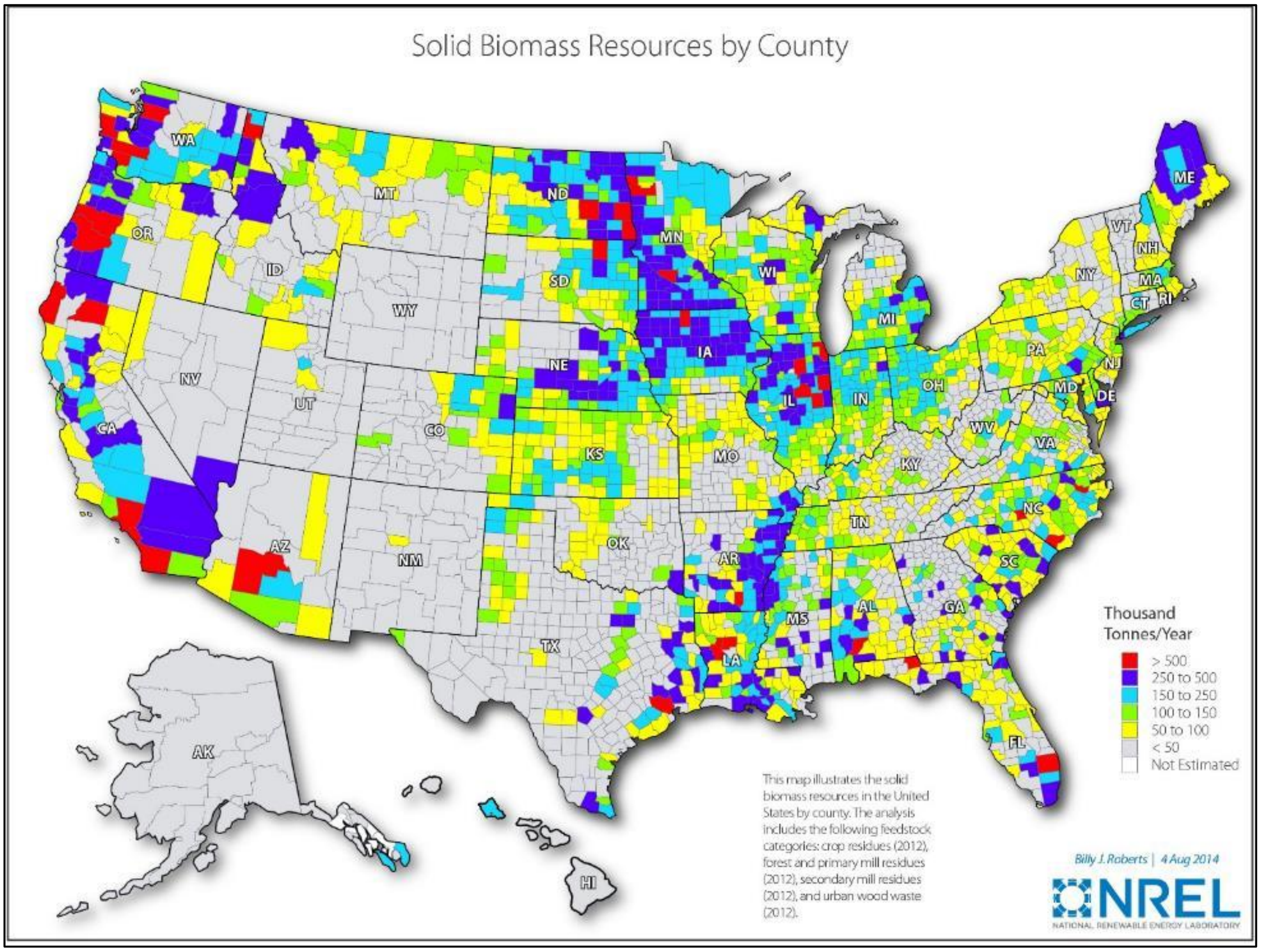


Source: 2017 NREL

Biomass (Wet and Dry Feedstocks)

Biomass can be used as a vital component for effective clean energy processes, such as anaerobic digestion substrate and gasification. Anaerobic digestion is a biological process that produces a biogas from organic wastes and gasification is a process that coverts organic materials into a valuable gas product. There is extensive biomass data available for California published by NREL in the Geospatial Data Science Center. This map compiles all of the data for every day of the year, for every portion of the state by county. Figure 3 shows the solid biomass resource by county and give a general overview for an initial assessment. Accurate ZNEF analysis will depend on the agricultural waste available on a specific piece of property or area. From Figure 3, the Central Valley Region, where San Joaquin Valley is located, ranges 150 to 500 thousand tonnes per year. Central Valley Region has a considerable range gap, so it is imperative to analyze the specific site for more credible data. For instance, considerations could be whether there is extensive cultivation of vineyards and orchards that produce lots of woody biomass waste, or whether there are dairies in the area that generate lots of manure that could be used as an anaerobic digestion or gasification substrate.

Figure 3: National Renewable Energy Laboratory Solid Biomass Resources Map by County



Source: 2017 NREL

To get a more precise calculation of data, Biodico used the Unites States Department of Agriculture (USDA) Biorefinery Stakeholder Information System (BioSIS); which is an extensive map data developed in conjunction with the Environmental System Research Institute (ESRI). The BioSIS tool assists with evaluating the feasibility and opportunities for locating a new biorefinery. The tool provides access to information on demographics, land use, biomass, feedstock, economics, and financial management. Using this tool, stakeholders can perform market and economic analysis on the viability of a renewable fuels project, and on the potential benefits of selling your feedstocks to a refinery rather than in the traditional sales market. The sustainability section of the tool allows users to assess GHG (CO_2) savings and the amount of petroleum fuels possibly replaced by biofuels.

Electrical Demand

Renewable energy resource potential needs to be compared to electrical demand in order to have a Zero Net Energy Farm. Electrical demand can be characterized in several ways.

Total kWh

Total kWh (kilowatt hours) is the total amount of electricity consumed. Watts are defined as volts multiplied by amps, so this is a very crude estimate of the total energy use. If it is for a year-long period, there can be significant differences in seasonal energy use. For instance, more air conditioning in the summer, and more heating and lighting energy in the winter. There can also be significant changes in annual energy use from year-to-year depending on the drought cycle. Drought years require farmers to pump water from wells, instead of getting water from the distribution canal. A 350 horsepower well pump running 24 hours a day can result in very substantial energy consumption.

Time of Use

Most energy consumers are now on a time of use (TOU) rate system. In theory, this incentivizes consumers to use less energy when demand is high and defer energy use until demand is lower. There are typically three TOU periods, peak, shoulder and non-peak.

Demand Charges

The service level maintained to a particular consumer depends upon the maximum electric demand, even if it is brief. Demand charges can amount to 30 percent or more of an electric charge and are usually computed on the maximum energy use during any 15-minute period during a billing period. If a consumer uses 250 kWh during a single 15-minute billing period and drops to 10 kWh for the rest of the time, the entire demand charge is based on 250 kWh.

Tariff Schedule

The amount that consumers pay for their electricity depends up the tariff schedule they have with their utility. Generally, tariffs are divided into residential, commercial and agricultural, but there are substantially variable tariffs within each category.

Technology Review – Metrics

Once potential renewable energy resources and electrical demand are known, the next step is to review which technologies are best suited for converting the resources into the kind of energy that is needed. Generally, energy production can be divided into two categories, intermittent and on-demand. Intermittent energy is available only when the renewable resource is available, for example, solar energy not produced at night and wind energy not produced on calm days.

Each type of renewable energy technology examined in a trade study to determine the vendors that are available, price capacity and size. This data was placed into a spreadsheet and embedded into the interactive map called the ZNEF GeoPlanner, so that configurations of each renewable resource technology could be installed on the selected property and output assessed, which can be seen in Table 1.

Table 1: Distributed Renewable Energy Spreadsheet

Manufacturer	AD	Battery	Gasifier	Solar	Wind	Watts Electric	Watts Heat	Watts Battery Capacity	$/watt electric	$/watt heat	$/watt battery	Price	Watts/Sq Ft
Aleko				x		250	0	0	$ 1.68	$ -	$ -	$ 419.00	23
Alfagy CHP				x		200	460		$ 0.13	$ 0.30	$ -	$ 285.00	46
Canadian Solar				x		315	0	0	$ 0.79	$ -	$ -	$ 248.00	15
Canadian Solar				x		320	0	0	$ 0.85	$ -	$ -	$ 273.00	15
DualSun				x		250	912	0	$ 0.11	$ 0.41	$ -	$ 599.76	65
Fafco/CoolPV				x		275	1,000	0	$ 0.10	$ 0.37	$ -	$ 600.00	71
LG				x		330	0	0	$ 1.00	$ -	$ -	$ 330.00	18
Panasonic				x		330	0	0	$ 1.15	$ -	$ -	$ 381.00	18
SmartFlower EV Charger		x		x		2,510	0	2,300	$ 2.39	$ -	$ 2.19	$ 22,000	80
Solar Systems				x		280	0	0	$ 0.89	$ -	$ -	$ 250.00	13
SolarZentrum CHP				x		200	715	0	$ 0.07	$ 0.24	$ -	$ 285.00	64
Tractor Port				x	x	75,000	0	0	$ 4.80	$ -	$ -	$ 360,000	
Aeolos					x	60,000	0	0	$ 1.36	$ -	$ -	$ 81,600	1
Aerotecture					x	2,500	0	0	$10.00	$ -	$ -	$ 25,000	6
Aleko					x	3,000	0	0	$ 0.43	$ -	$ -	$ 1,300	3
Aleko					x	1,500	0	0	$ 0.57	$ -	$ -	$ 850	2
Aleko					x	900	0	0	$ 0.56	$ -	$ -	$ 500	1
Aleko					x	700	0	0	$ 1.06	$ -	$ -	$ 744	3
Bergey					x	10,000	0	0	$ 4.20	$ -	$ -	$ 41,950	2
Change Wind					x	36,000	0	0	$ 2.01			$ 72,468	
Eastern Wind Power					x	50,000	0	0	$ 3.20	$ -	$ -	$ 160,000	22
Enessere					x	3,500	0	0	$28.57	$ -	$ -	$ 100,000	5
Hurricane					x	1,000	0	0	$ 0.84	$ -	$ -	$ 840	3
Missouri Wind & Solar					x	1,600	0	0	$ 0.23	$ -	$ -	$ 370	7
My Solar Mill				x	x	1,300	0	0	$ 2.40	$ -	$ -	$ 3,125	2
Norther Power Sytems					x	100,000	0	0	$ 4.20	$ -	$ -	$ 419,500	2
Pacific Sky Power					x	15	0	0	$ 3.93	$ -	$ -	$ 59	1
PowerWorks					x	100,000	0	0	$ -	$ -	$ -		3
R&X Technology				x	x	600	0	0	$ 0.59	$ -	$ -	$ 355	4
SAWT					x	5,000	0	0	$ 4.65	$ -	$ -	$ 23,233	1
Southwest Wind Energy				x	x	3,800	0	0	$ 3.16	$ -	$ -	$ 12,000	3
Tractor Port				x	x	55,500							
Windside					x	2,000	0	0	$ 8.75	$ -	$ -	$ 17,500	19
WindSpire					x	5,000	0	0	$ 5.20	$ -	$ -	$ 26,000	11
Kingdo (10,000 gal)	x					0	514,860	0	$ -	$ 0.08	$ -	$ 39,800	9,406
Paques (gallons)	x					0	1,210,000	0	$ -	$ 0.99	$ -	$ 1,200,000	12,100
Schumann	x					0	1250000	0	$ -	$ 0.20	$ -	$ 250,000	12,500
All Power Labs			x			20,000	19,000	0	$ 0.33	$ 0.31	$ -	$ 25,000	2,438
AgriPower			x			1,000,000	900,000		$ 0.97	$ 0.87	$ -	$ 3,500,000	760
Biogen			x			750,000	500,000		$ 0.72	$ 0.48	$ -	$ 1,500,000	500
Community Power Corporation			x			130,000	73,000		$ 3.54	$ 1.99	$ -	$ 1,121,000	226
Entrade			x			25,000	60,000		$ -	$ -	$ -		531
Entrade			x			50,000	120,000		$ -	$ -	$ -		1,063
Froling			x				150,000		$ -	$ 0.43	$ -	$ 65,000	500
Waste to Energy Systems			x			200,000	200,000		$ 0.63	$ 0.63	$ -	$ 500,000	167
AES Energy Storage		x											
Aquion Energy		x						25,900	$ -	$ -	$ 0.58	$14,995	1,573
Axion PbC		x						500,000	$ -	$ -	$ 0.51	$255,000	1,563
Enphase		x						1,200	$ -	$ -	$ 1.58	$ 1,900	1,290
LG		x						9,800	$ -	$ -	$ 0.63	$ 6,154	5,946
Mercedes		x						2,500	$ -	$ -	$ 4.00	$ 10,000	1,478
Panasonic		x						8,000	$ -	$ -	$ 0.50	$ 4,000	4,729
Skeleton Capacitors		x						830	$ -	$ -	$52.94	$ 43,940	#DIV/0!
SonnenEco (single phase only)		x						16,000	$ -	$ -	$ 1.43	$ 22,800	8,533
Tesla		x						95,000	$ -	$ -	$ 0.47	$44,500	6,923

Source: 2018 Biodico

Solar PV, Thermal and CHP, Intermittent

Solar energy is only available when the sun is shining, so this is referred as intermittent energy. It is not available at night, and its intensity is reduced on cloudy days. NREL's System Advisory Model (National Renewable Energy Laboratory, 2018) gives an annual capacity factor for solar depending upon (1) the type of installation including fixed mount, single axis or dual axis, (2) the latitude and longitude to derive astronomical data, and (3) the geographic location to determine weather characteristics.

Solar energy can be converted into electricity, heat or both. The associated solar technologies are called solar PV, solar thermal and solar combined heat and power (CHP). Large concentrated solar thermal installations are infamous for creating the potential for bird and bat mortality. Files are kept for each vendor and are continually being update as new technologies emerge and older technologies are retired. Examples of solar vendor products are given in the appendices.

Wind Turbines, Intermittent

Wind energy is only available when the wind is blowing, so it is called intermittent energy. Wind energy and solar energy are both intermittent energy types, but their intermittency can occur in different cycles. NREL's System Advisory Model (National Renewable Energy Laboratory, 2018) gives an annual capacity factor for wind depending upon (1) the type of technology including vertical and horizontal axis turbines, and (2) the geographic location to determine weather characteristics including wind velocity. Wind energy can only be converted directly into electricity, which can be used to provide electric power or power heating elements. Files are kept for each vendor and are continually being updated as new technologies emerge and older technologies are retired. Examples of wind vendor products are given in the appendices.

Horizontal Axis

Horizontal axis wind turbines look like propellers that are mounted horizontally to the wind and parallel to the ground. The pivot so that they are directly facing the wind for maximum power and point away from the wind or feather their blades if the wind force exceeds their capacity. They range in power ratings from fractions of a watt to megawatts. Large wind turbines are infamous for creating the potential for bird and bat mortality.

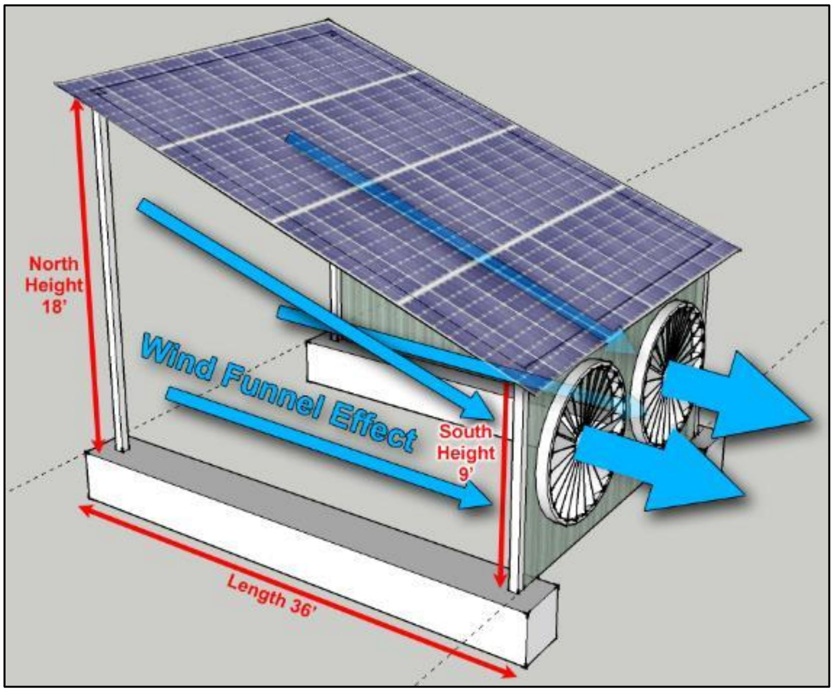
Vertical Axis

Vertical axis turbines look like egg beaters and are mounted vertically to the wind and perpendicular to the ground. They are generally more expensive and less efficient than horizontal axis wind turbines, but they are not known for creating the potential for bird and bat mortality. They do not pivot with the wind and are capable to generating wind from any direction.

Tractor Ports

The tractor port combines solar PV and ground mounted horizontal axis wind turbines. The solar PV mounting acts as a wind scoop to enhance ground level winds and shielding helps to prevent bird and bat mortality. Since the mouth of the wind scoop faces south in order to maximize solar power potential, tractor ports are most efficient if the wind direction is predominantly from the north. An example of a tractor port is shown in Figure 4.

Figure 3: Tractor Port



Source: Biodico

Anaerobic Digestion, Thermal and CHP, On-Demand

Anaerobic digestion (AD) is a biological process that microbially converts hydrocarbons to biogas, which is predominantly methane (CH_4), carbon dioxide (CO_2) and sulfur dioxide (SO_2). The microbes operate in an oxygen-free environment at either a mesophilic (68˚F to 113˚F) or thermophilic (109˚F to 131˚F) temperatures. Generally, thermophilic AD produces more biogas quicker than mesophilic AD, but is much less stable and more energy intensive because of heating requirements. Biogas typically needs to achieve the maximum concentration of CH_4 and the maximum removal of CO_2, SO_2 and water vapor in order for it to be used in generators and boilers.

Substrate water content can vary depending upon the design, but generally operate more efficiently than gasifiers at a water content of 30 percent or more. AD efficiency is defined by the hydraulic retention time, organic loading rate and volatile destruction, and varies by AD design.

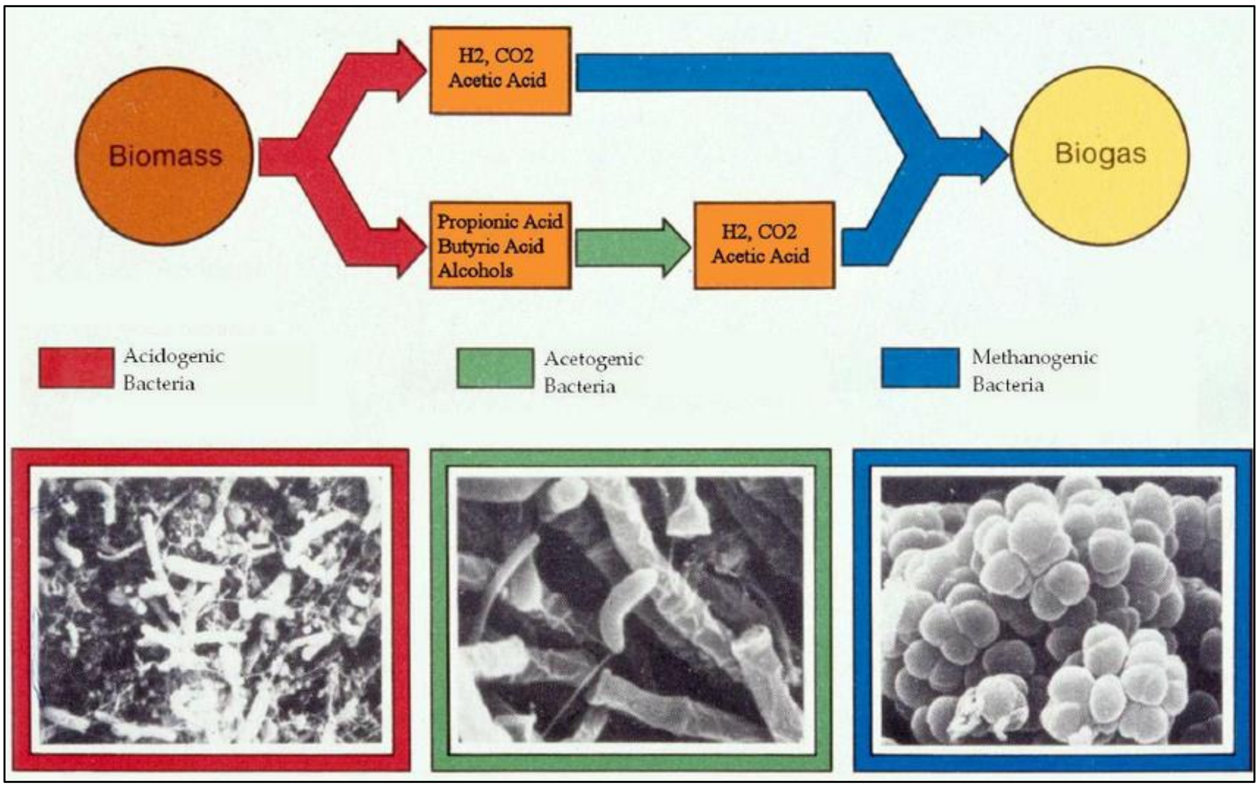
Hydraulic Retention Time

Hydraulic retention time is the amount of time that the material that is being digested (substrate) spends in the digester. For example, it is not unusual for dairy manure to spend 40 days in a lagoon digester. If the dairy is generating 1,000,000 gallons of manure per day, then the size of the lagoon digester needs to be at least 40,000,000 gallons. In contrast, an expanded granule sludge digester (EGSB) requires a hydraulic retention time of only one day, and so its size would be at least 1,000,000 gallons or 40 times less than a dairy digester lagoon.

Organic Loading Rate

AD depends on many different types of microbes to efficiently digest substrate (Scherer, 2007). Many of these operate in sequence with one microbe consuming a type of nutrient and producing another type of nutrient which is consumed by the next type of microbe, and so on, (Figure 5).

Figure 4: Anaerobic Digestion Microbial Communities



Source: 2007 Scherer

Organic loading rate is the volume of substrates that can be fed into the digester. The maximum amount is defined by the amount of organic acids produced by the first colony of microbes, the acidogenic bacteria. If the organic loading rate is too high, the digester turns too acidic and kills the other microbes. If the organic loading rate is too low, the digester does not produce much biogas. The Goldilocks scenario is to approach 100 percent of the maximum organic loading rate, but not exceed it. Biodico has developed a series of automated sensors that indicate and modulate the organic loading rate.

Volatile Destruction

Volatiles are the digestible portion of the substrate that is fed into AD. The comparison of volatiles in the substrate versus the volatiles present in the effluent at the end of the digestion process, give the percentage of volatile destruction. Typically, AD yields a 40-60 percent volatile destruction. In advanced AD designs this can increase to as much as 90 percent, which results in more biogas.

Design Types

Plug Flow

A plug flow digester is similar to a big tube of toothpaste or animal intestines. Substrate enters a chamber and progresses through the chamber without being mixed for 30-40 days. It can be made out of plastic sheeting for both the digester and the biogas storage bladder (seen in the photo below). Biogas is typically not cleaned and is used for small cooking stoves. This is the most basic type of AD and is used in many emerging rural areas of the world. It operates at mesophilic temperatures and uses substrates that are low in volatiles and high in solids.

Continuous Stirred Reactor

A continuous stirred reactor consumes more liquid substrates and involves one or multiple reactors into which the substrates are added and then thoroughly mixed. This is a more advanced type of digester and results in better biogas production. The biogas is usually cleaned and used in generators or boilers. This technology is widely practiced in Germany and is successful at farm-scale, an example shown in Figure 6. It operates at mesophilic and thermophilic temperatures.

Figure 5: Continuous Stirred Reactor Anaerobic Digestion

Source: 2015 Biodico

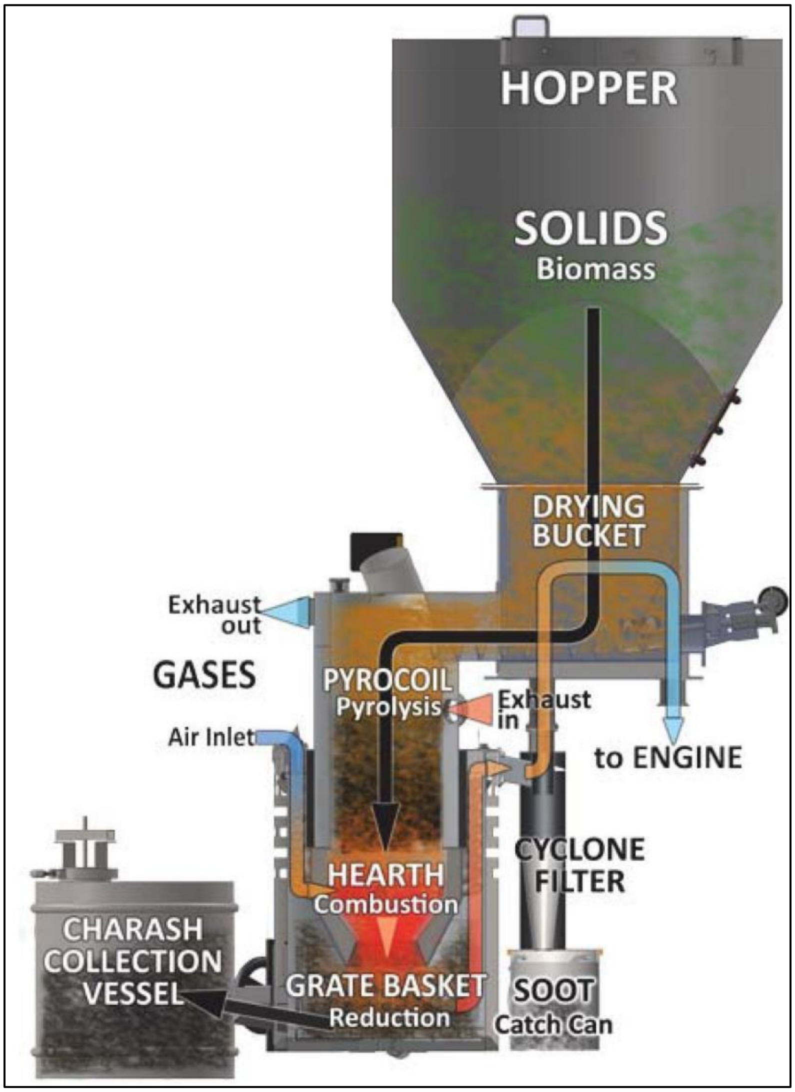
Expanded Granular Sludge Bed

There are many other types of AD systems, but perhaps the most advanced is the expanded granular sludge bed digester (EGSB). EGSB is best suited for less than 3 percent non-volatile solids and has a very low hydraulic retention time of 12-24 hours and a very high volatile destruction rate of 90 percent. It operates at mesophilic temperatures but requires more complexity in the digester.

Gasifiers Thermal and CHP, On-Demand

Gasifiers operating thermochemically in a low oxygen environment to convert hydrocarbons to syngas, which is composed principally of hydrogen and carbon monoxide, an example shown in Figure 6. Gasifiers are most efficient with feedstocks containing 30 percent or less of water, such as woody biomass waste from orchards and vineyards. Gasifiers are generally exothermic. Syngas can be used in generators and boilers.

Figure 7: Gasifier Process



Source: 2017 All Power Labs

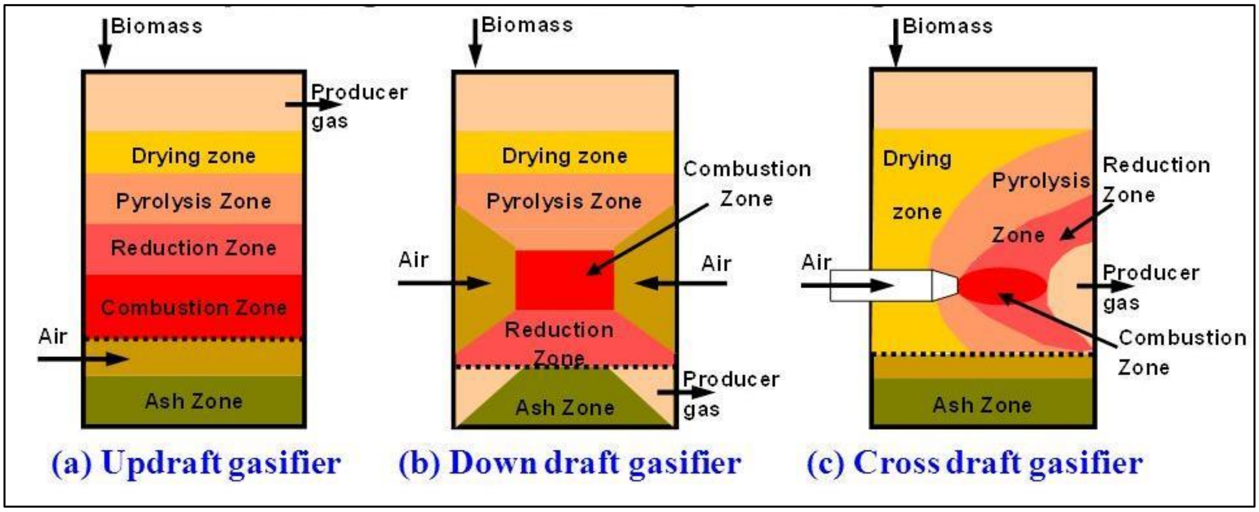
Alternatives

There is a significant amount of woody biomass waste from orchards and vineyards in California, which was usually disposed of in large biomass-to-energy facilities located near biomass resources. However, these facilities are closing as their 20-year power purchase agreements end and farmers have had to resort to open burning of woody biomass, which has a severe impact on air quality. (San Joaquin Valley Air Pollution Control District, 2017)

Types

Gasifiers are generally updraft, down draft or cross draft depending on the flow of gas through the fuel bed is shown in Figure 8. (Chandak, 2013)

Figure 8: Gasifier Types



Source: 2013 Chandak

Biochar

Biochar is residual carbon left over after biomass gasification. It is frequently used as a soil amendment with many beneficial qualities, including carbon sequestration. (International Biochar Initiative, 2018) Some soil and atmospheric benefits include:

- Decreasing nutrient runoff while increasing soil carbon,
- Improving soil fertility and tilth,
- Capturing carbon to create carbon negative energy, and
- Reducing odor, methane, and N_20 soil emissions

Energy Storage, On-Demand

Intermittent power sources, such as wind and solar, can be converted to on-demand power through the use of energy storage. Intermittent power is stored in a specific medium depending upon the technology and later retrieved when it is needed. There are many forms of energy storage. This report will only cover the energy storage mediums that are commercially viable for agricultural applications. (Huggins, 2010)

Smart Batteries

One of the most developed and commercially viable energy storage systems is the smart battery. There are many manufacturers for these systems and they use various types of batteries from lead acid to lithium ion. All of these systems have several components (1) the storage batteries, (2) inverters to convert low voltage direct current power to higher voltage alternating current compatible with the grid, and (3) intelligent systems analysis to respond to automated dispatch requests and consumer demand. Systems are rated on cost, life span, recycling efficiency and intelligence.

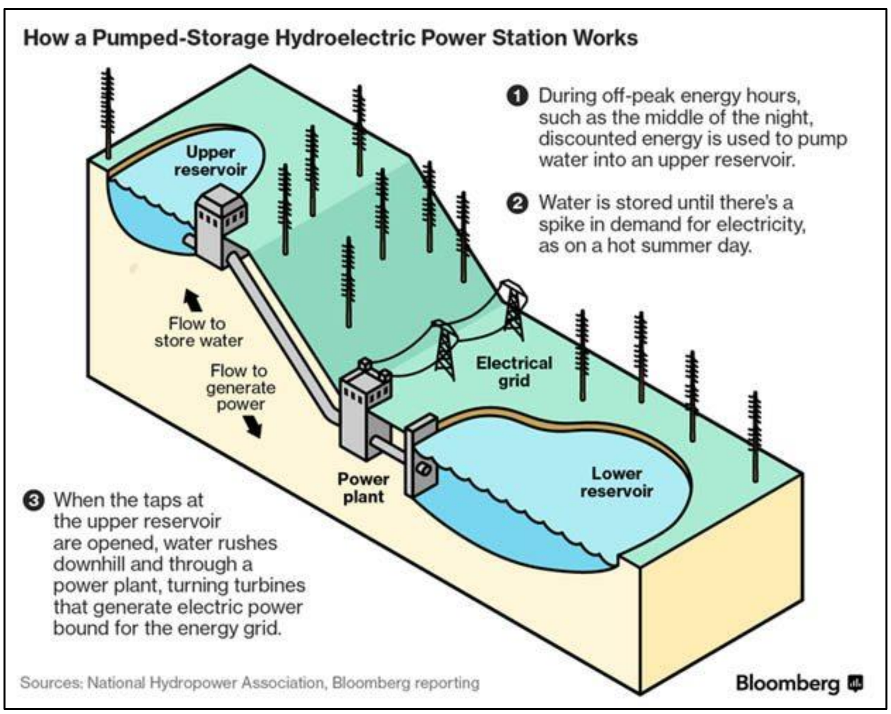
Vehicle-to-Grid

Vehicle-to-grid (V2G) technology uses the batteries in an electric vehicle to dispatch energy to the grid or for consumer use. It is a bidirectional charger in that it accepts a charge to fill up the batteries and it reverses the flow of electricity to discharge the batteries to the grid or for consumer use. (Nuvve, 2018)

Elevated Water

Electricity from intermittent sources is used to pump water to a tower or up to a reservoir, and then when there is a demand for power, the water is released, and the flowing water runs turbines to generate electricity. Most reservoirs in California have this capability. They have a forebay at the bottom of the reservoir for storing water to be pumped up to the reservoir. The flow of water is reversed when power demands on the grid need to be met and seen in Figure 9. (US Department of Energy, 2016)

Figure 9: Pumped-Storage Hydroelectric Power

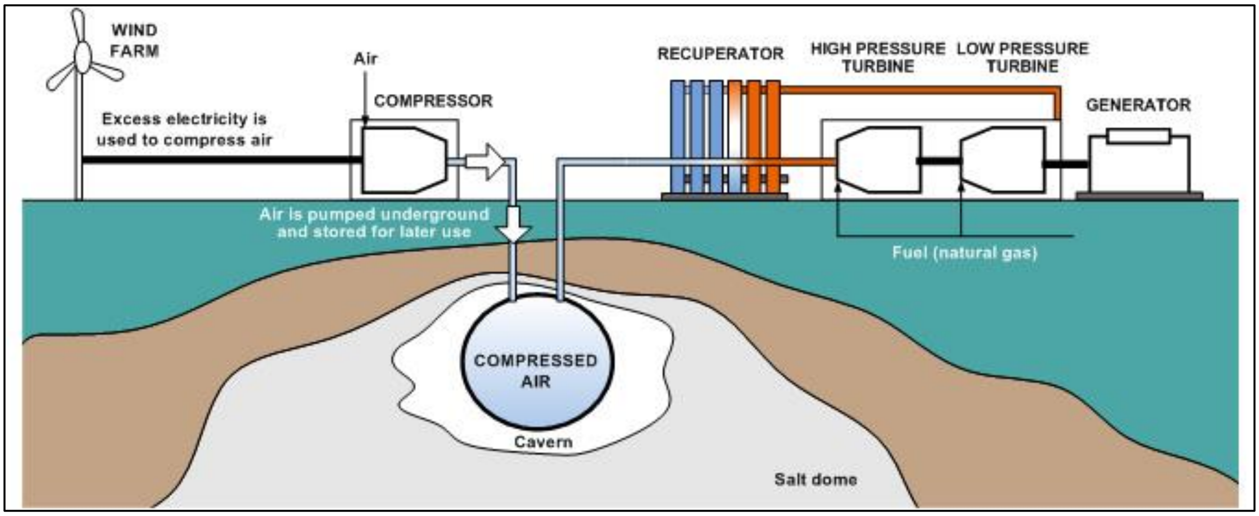


Source: 2016 National Hydropower Association

Compressed Air Energy Storage

Compressed air energy storage systems (CAES) use electricity to pump air into a compressed air tank and then release the compressed air to drive a turbine when electricity needs to be generated and seen in Figure 10. (J. I. San Martín, 2011)

Figure 10: Compressed Air Energy Storage System

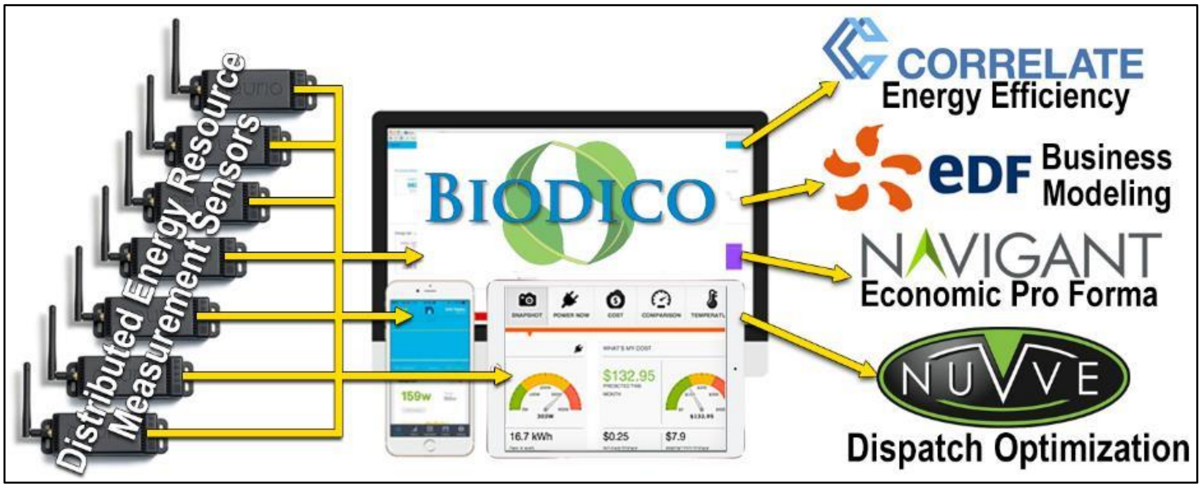


Source: 2011 San Martin

Measurement and Verification

The measurement and verification plan (M&V Plan) for this project is based on data flow from WiFi-enabled sensors (such as Neurio) with Cloud compiling to a dashboard accessible on PCs, tablets and smart phones. The metrics used will be subject to the Energy Commission's approval, but should include before and after energy efficiency comparisons, the volume, intensity and reliability of each DER, the number, duration, response time and type (kWh/frequency) of dispatch requests, and the economic case and business model for each DER separately and comprehensively. Demand response, energy efficiency, V2G, distributed renewable generation (DRG), water use and GHG reduction will all be subject to the metrics defined in the M&V Plan that will continue for a minimum of 12 months of operation during the project and for a period of at least 3 years after the project has ended with the Energy Comission. Figure 11 outlines the flow of data and functions of the M&V Plan.

Figure 11: Measurement and Verification Plan



Source: 2018 Biodico

This project will use established and newly developed tools to measure and quantify project benefits. This will include pre/post project energy using Normalized Metered Energy Consumption (NMEC) analysis and International Performance Measurement and Verification Protocol (IPMVP).

Sensors

The sensors to be used in the measurement and verification plan are Wi-Fi enabled devices that capture data on net energy use and individual component usage, such as tractor ports, solar panels on the production side, and ovens, dryers and lights on the demand side. Several manufacturers produce smart sensors such as Neurio, and exmales are shown in Figure 29.

Expertise

Correlate will be responsible for energy efficiency, EDF Innovations for business modeling, Navigant for economic pro formas, and Nuvve for dispatch optimization. Biodico will be responsible for compiling the information and evaluating the GHG impacts, economic development improvements and outreach effectiveness.

Virtual Power Plants, Automated On-Demand

Virtual Power Plants (VPP) aggregate separate energy production and demand shedding, control them, and respond to automated dispatch requests from the California Independent System Operator (CA ISO) and utilities, example of a VPP is shown in Figure 12.

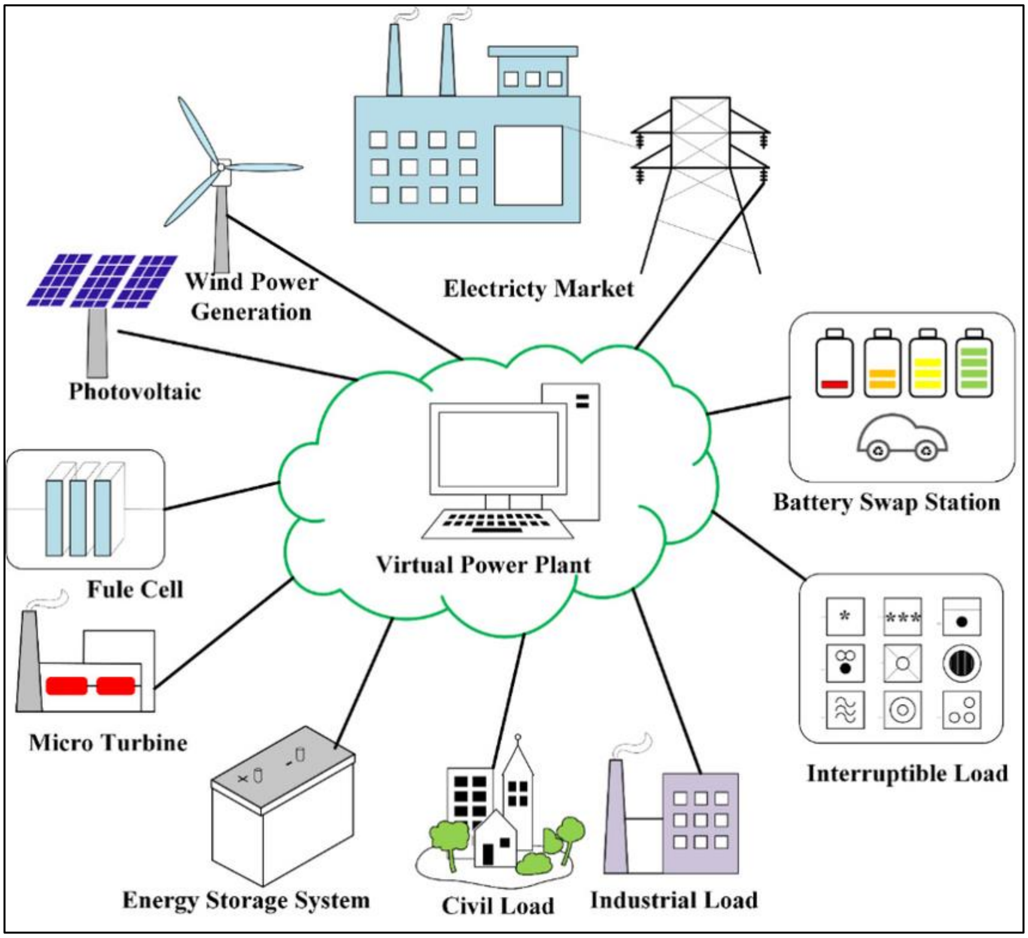
Definition

A virtual power plant (VPP) is a cloud-based distributed power plant that aggregates the capacities of heterogeneous Distributed Energy Resources (DERs) for the purposes of enhancing power generation, as well as trading or selling power on the open market. (Hao Bai, 2015) The VPP essentially combines the power generated from many DERs into a single combined pool of generated power.

Pros and Cons

VPP have a great deal of potential, but they exist in a nascent regulatory market that is subject to change. They have the potential to generate increase revenue for distributed renewable energy producers that are too small to respond to California ISO and utility requests.

Figure 12: Virtual Power Plant

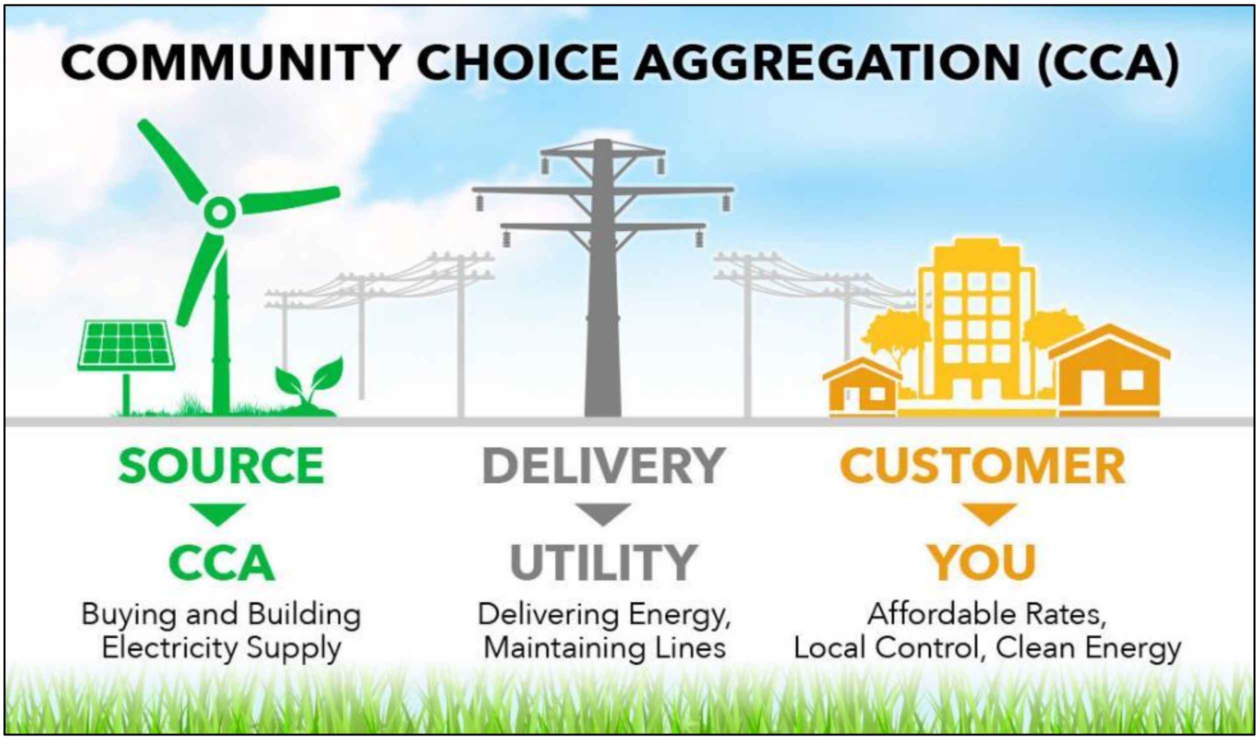


Source: 2015 Hao Bai

Community Choice Aggregation

Community Choice Aggregation (CCA) is a program that allows cities and counties to buy and/or generate electricity for residents and businesses within their areas, seen in Figure 13. (Pacific Gas and Electric)

Figure 13: Community Choice Aggregation



Source: 2017 Los Angeles County Supervisor Sheila Kuehl

Pros and Cons

The pro CCA advocates claim that customers will have affordable rates, local control and clean energy. The con side is that CCAs can be administered by inexperienced operators. A comparison of rates by PG&E shows that California community choice organizations charge their customers more than normal PG&E rates for "non-green" electricity.

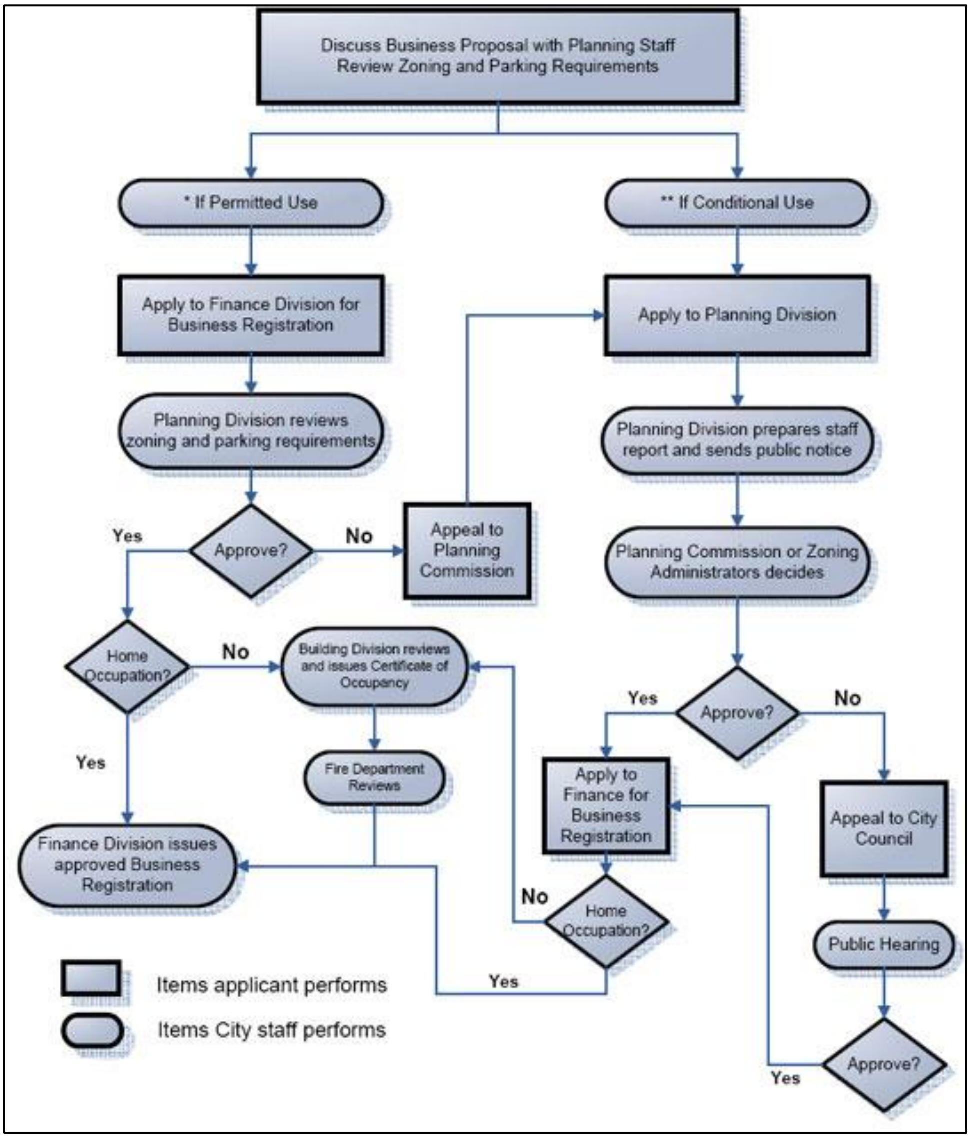
Permitting Plan

Once a resources assessment has been conducted and the appropriate combination of technologies selected, it is necessary to obtain permits for construction and operation. A consulting engineer and a land use attorney should be retained at this point.

Zoning – Conditional Use Permits

To assess the correct zoning conditions for this project, many questions needed to be addressed first, such as, is the zoning correct for the type of activity contemplated? Is a conditional use permit required? In most cases a Conditional Use Permit CUP will be required and the process is shown in Figure 14. A preliminary meeting with the jurisdiction in charge of permitting and zoning should be set up before a decision is made to move forward with the project.

Figure 14: Conditional Use Permit Process Flow Chart

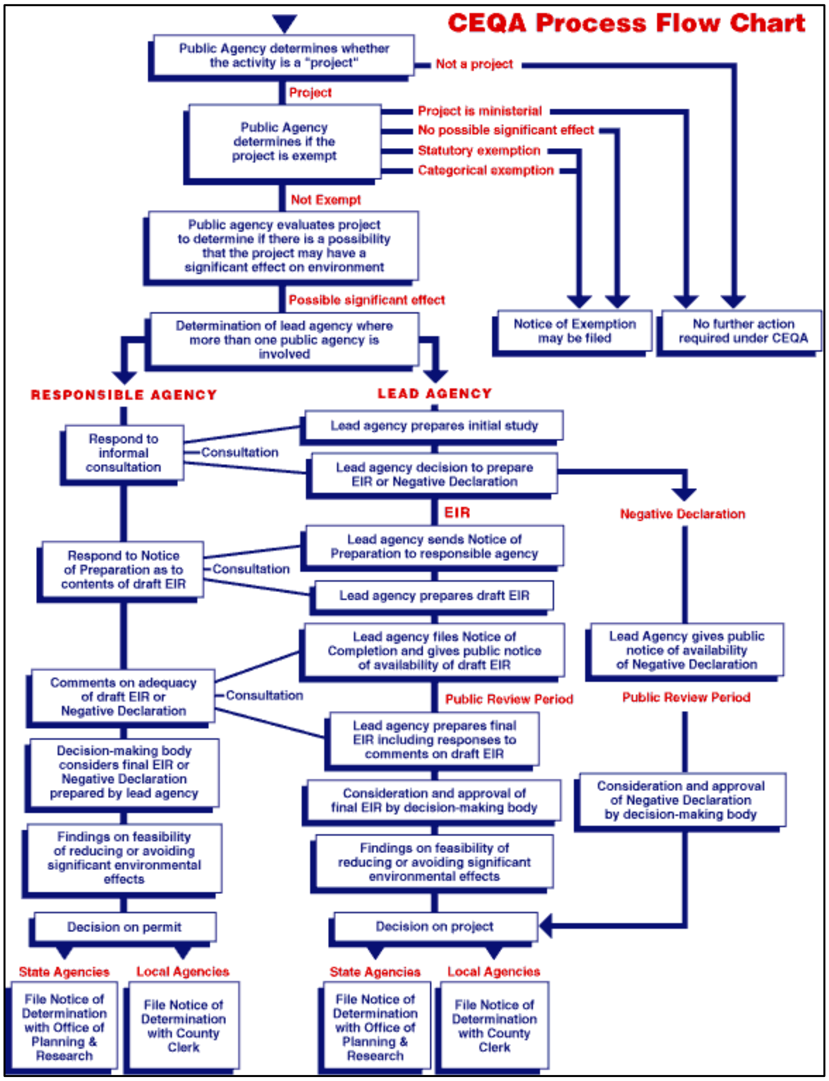


Source: 2018 City of San Carlos, CA

California Environmental Quality Act

California Environmental Quality Act (CEQA) is a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible. Most proposals for physical development in California are subject to the provisions of CEQA, as are many governmental decisions which do not immediately result in physical development (such as adoption of a general or community plan). Every development project which requires a discretionary governmental approval will require at least some environmental review pursuant to CEQA, unless an exemption applies. The "lead agency" for a specific jurisdiction will shepherd the project through the CEQA process and the result will be reviewed by many agencies through the State Clearing House and the process is shown in Figure 15. (California Natural Resources Agency)

Figure 15: California Environmental Quality Act Process Flow Chart

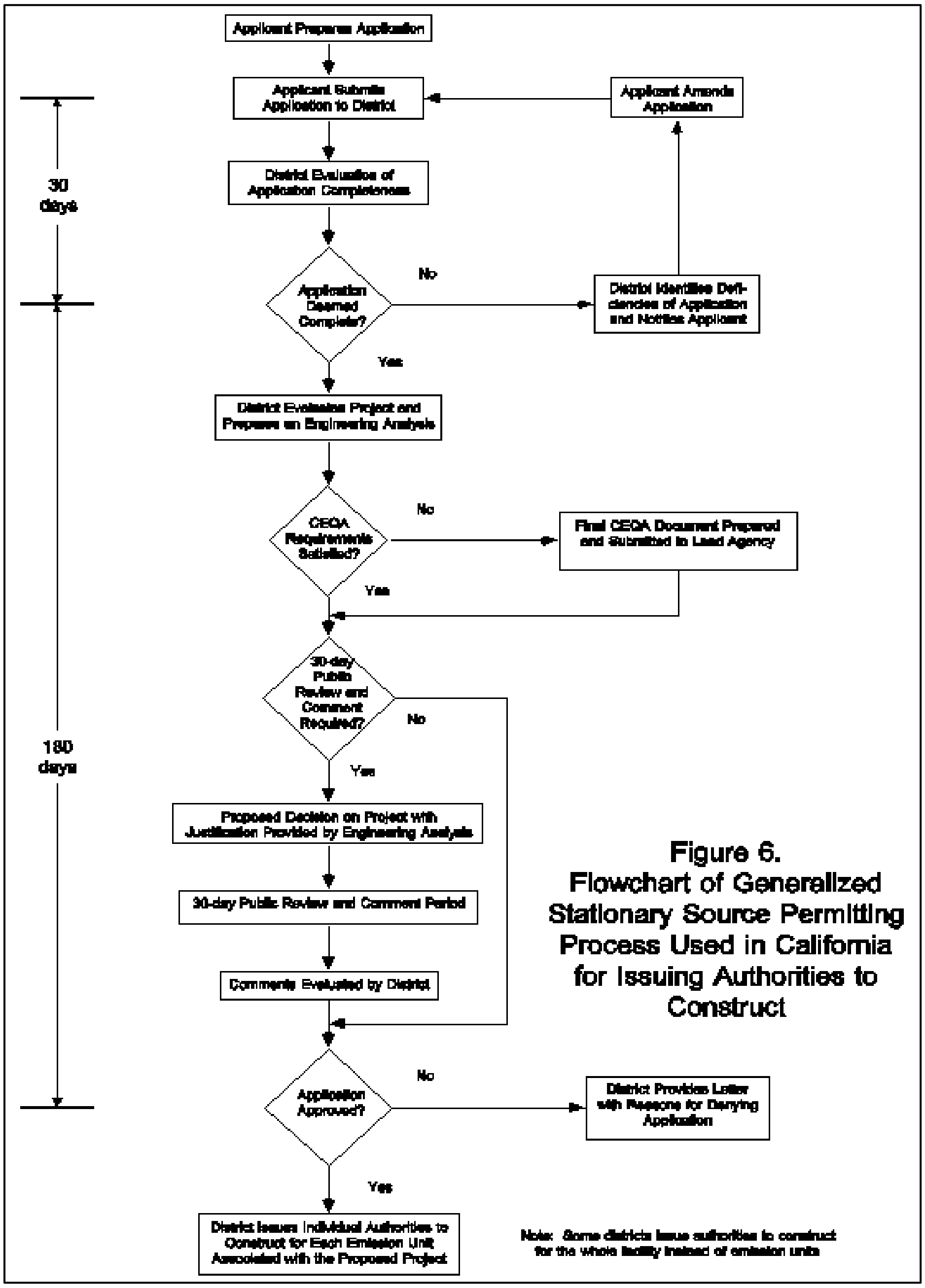


Source: 2015 CA Natural Resources Agency

Air District Permits

Perhaps the greatest hurdle will be in obtaining an authority to construct and an authority to operate from the local air district. This is especially true for gasifiers and anaerobic digesters. An engineering analysis is usually performed to assess emissions and air quality impacts, as well as to document compliance of the project with all applicable district and state requirements and the process is shown in Figure 16. (California Air Resources Board, 2017)

Figure 16: Air District Permitting Process Flow Chart

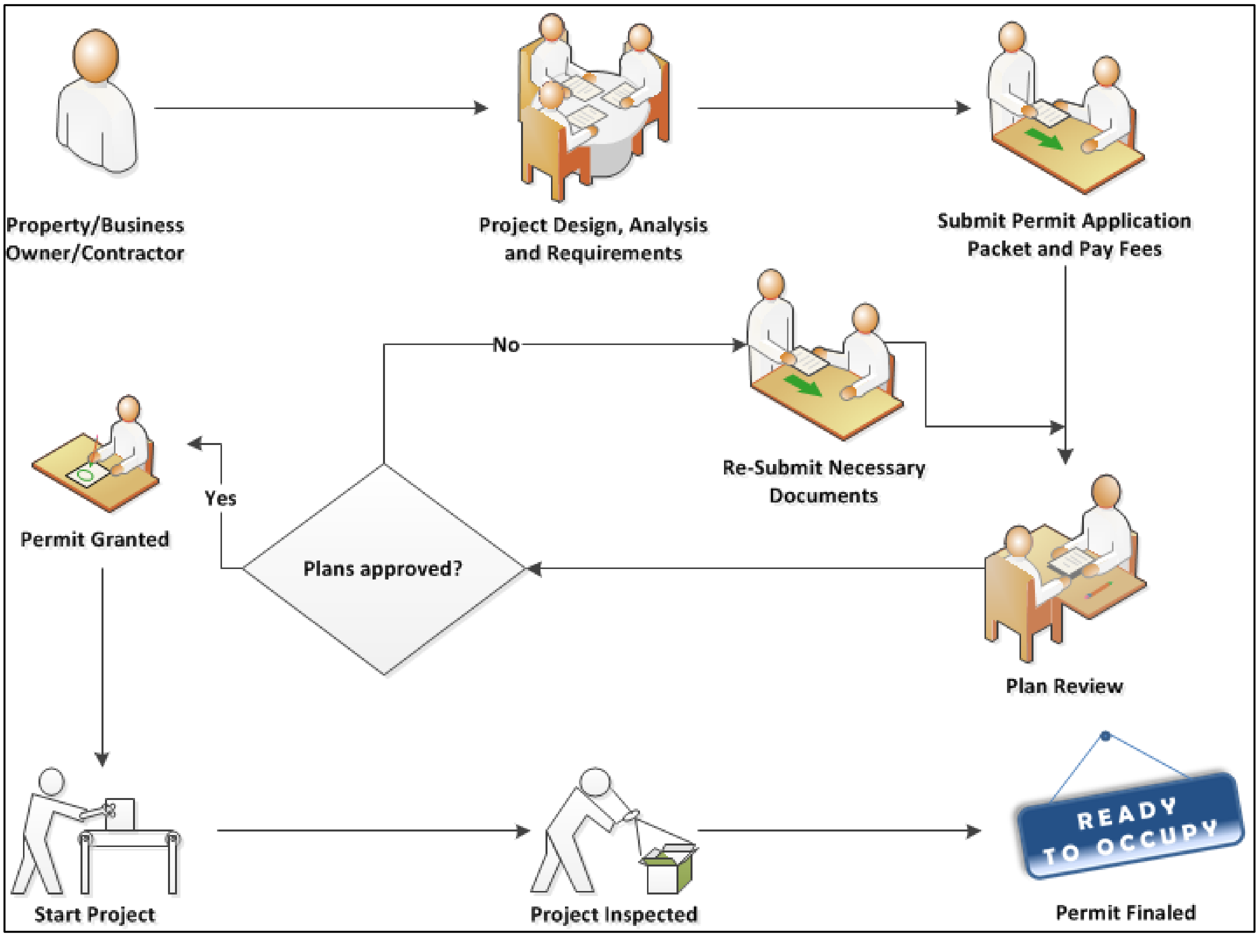


Source: 2017 CA Air Resources Board

Building Permits

Building permits applications need to be prepared for each element of the energy installation. If a vendor has been selected, this can usually be done by the vendor. The level of detail will depend on the project and the process is shown in Figure 17. Soil engineering and a seismic analysis may be required for foundations, containment pads and tanks.

Figure 17: Building Permit Process Flow Chart

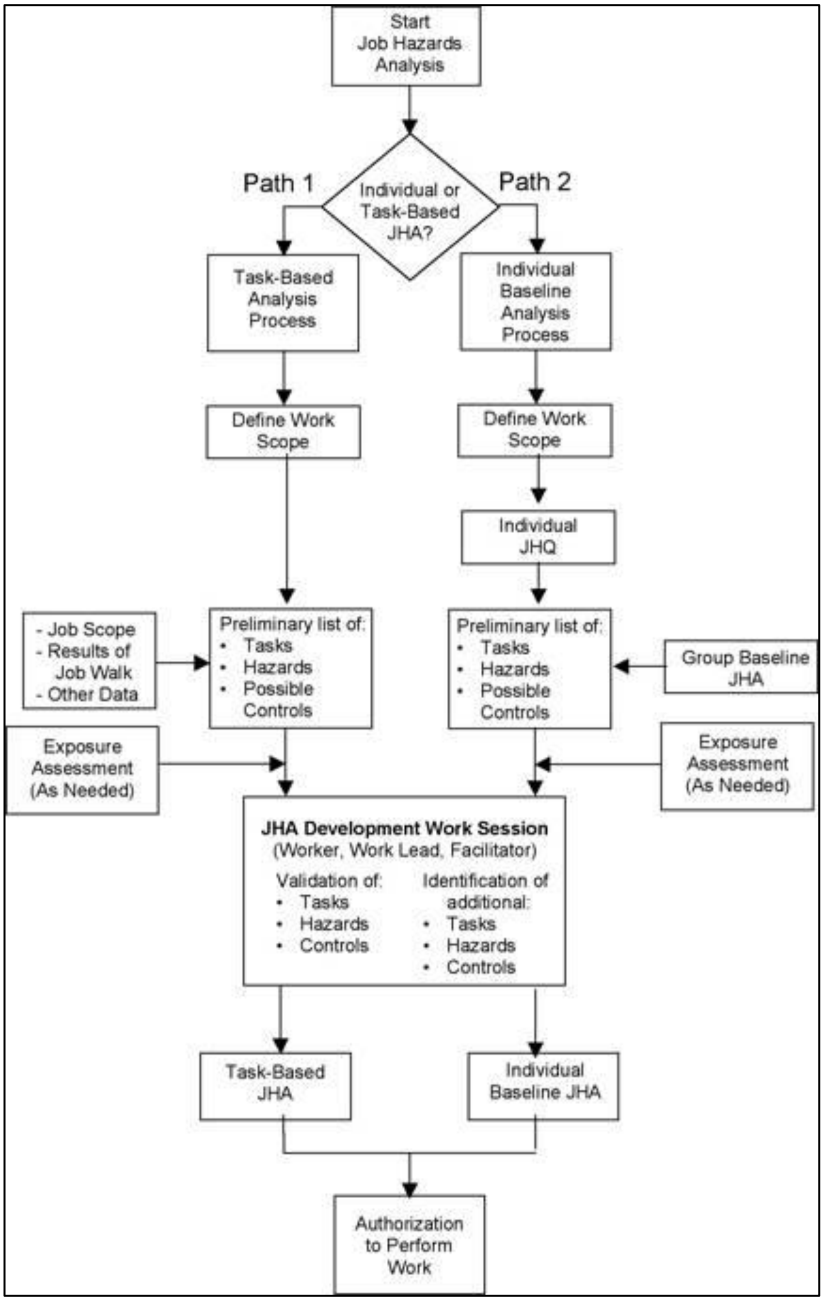


Source:2018 Alameda County

Health and Safety Plan

A health and safety plan, together with an operation manual should be prepared for each project. A part of the work planning process, workers and managers are required to plan all work: determine the tasks that will be performed, consider the hazards, risks, and concerns associated with those tasks, and implement appropriate controls. The primary tool for work planning is the Job Hazards Analysis (JHA) and the analysis is shown in Figure 18. (Berkeley Laboratory, 2014)

Figure 18: Job Hazard Analysis

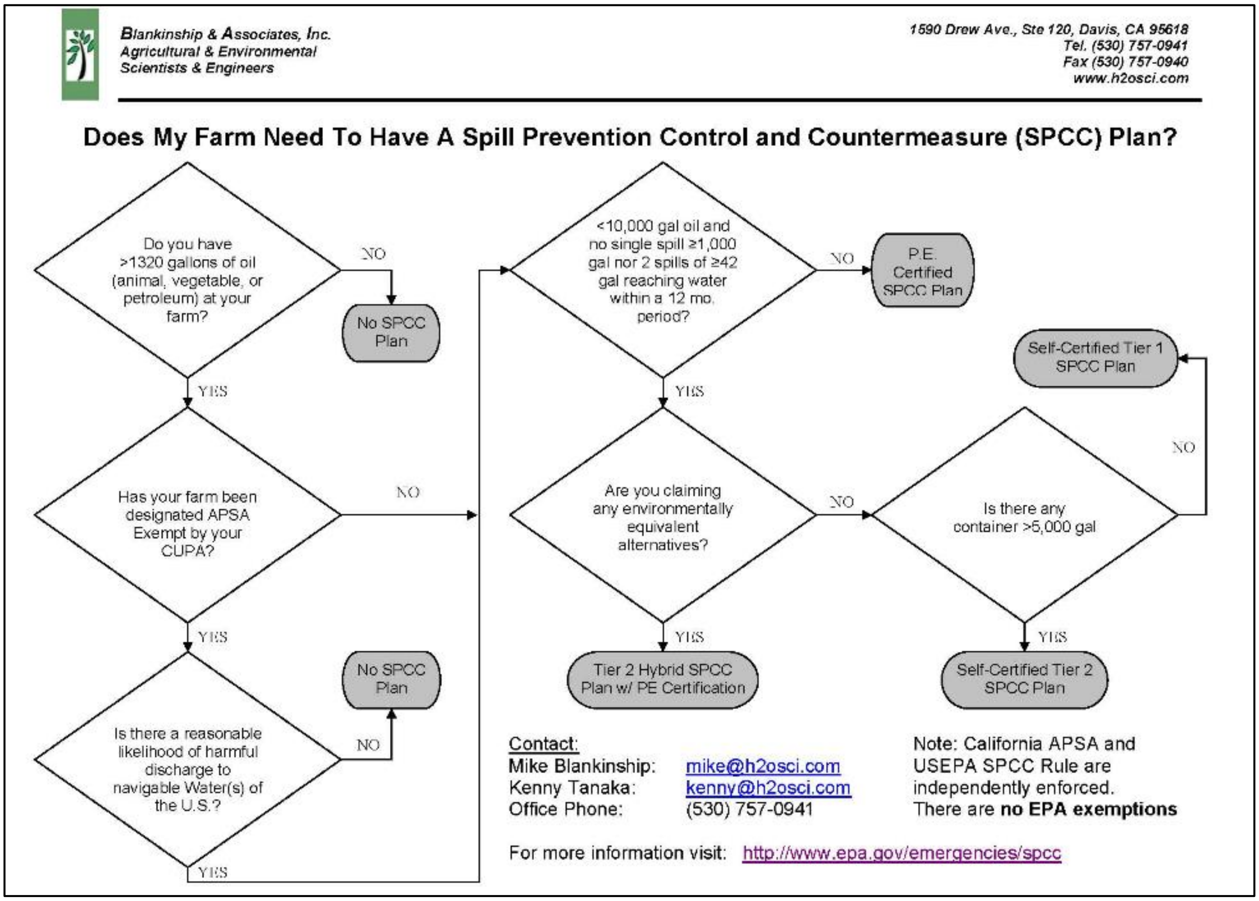


Shown: 2017 Berkeley Laboratory, US DOE

Spill Prevention and Control Countermeasure Plan

A Spill Prevention Control and Countermeasure (SPCC) Plan is a specific legal requirement that must be met under certain circumstances, which is shown in Figure 19. It is best to hire a consulting engineer to determine if this is required, and if it is, have them prepare a SPCC.

Figure 19: Spill Prevention Control and Countermeasure

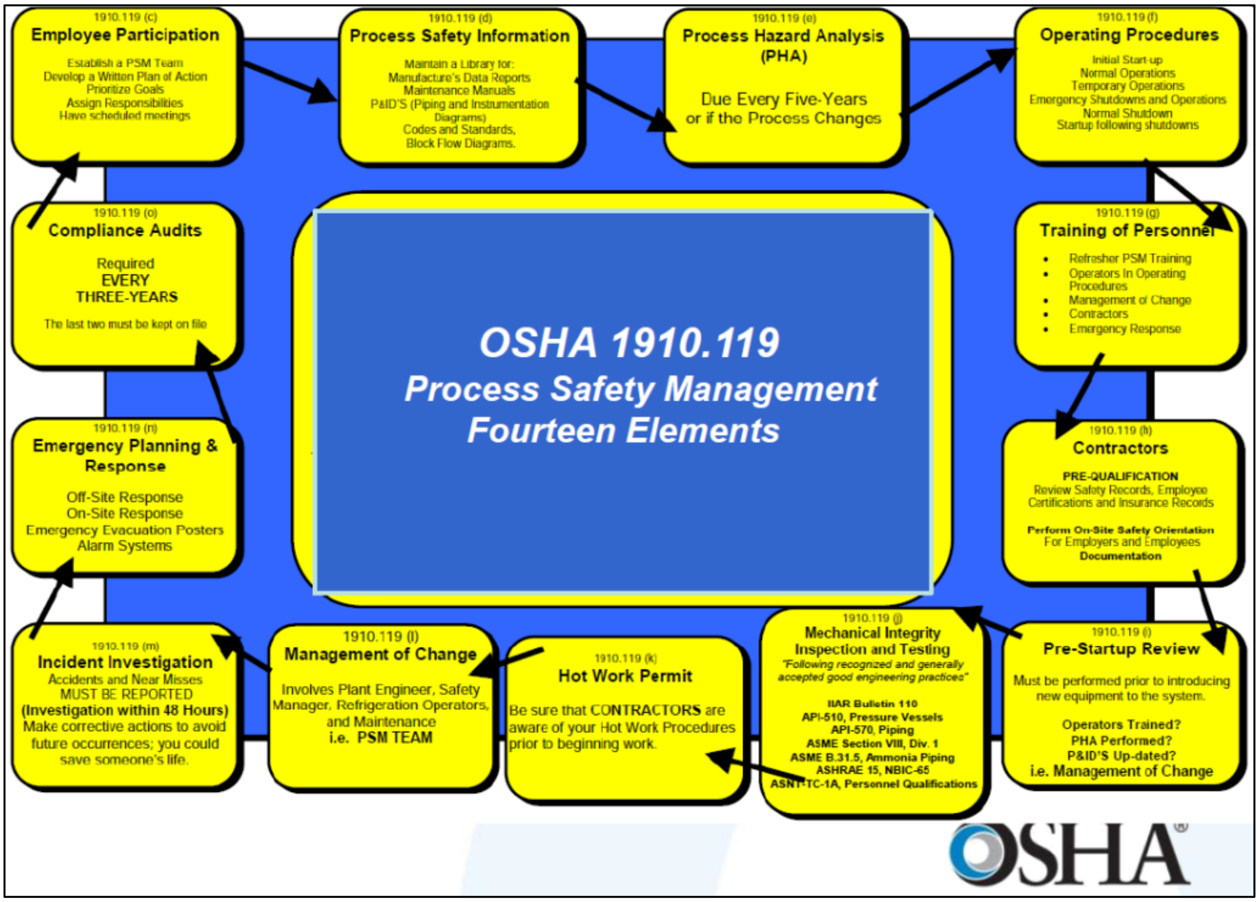


Source: 2017 Blankinship and Associates, Inc.

OSHA

The Occupational Safety and Health Act requires that a process safety plan be developed, implemented and audited and shown in Figure 20.

Figure 20: Occupational Safety and Health Act Process Safety Management Elements



Source: 2018 OSHA

Financing Strategies

Once the resource assessment, technology acquisition decision and permitting are under way, it is time to start the financing process. A business plan and financial pro formas should be put together so that the amount of financing can be determined, and a reasonable likelihood of return can be established for lenders, investors and guarantors.

Conventional Financing

Loans

Loans can usually be made through conventional lending institutions, such as banks and credit unions, and are shown in Figure 21. Loans are heavily tied to collateral and the ability to repay the loan, and usually will not be made for in excess of 80 percent for a renewable energy project, if at all. Small-scale renewable energy projects are considered by conventional lenders to be risky and it may be difficult to find a lender willing to finance such a project. Online lenders may be a more viable option. (Magnify Money, 2015)

Figure 21: Loan Requirements

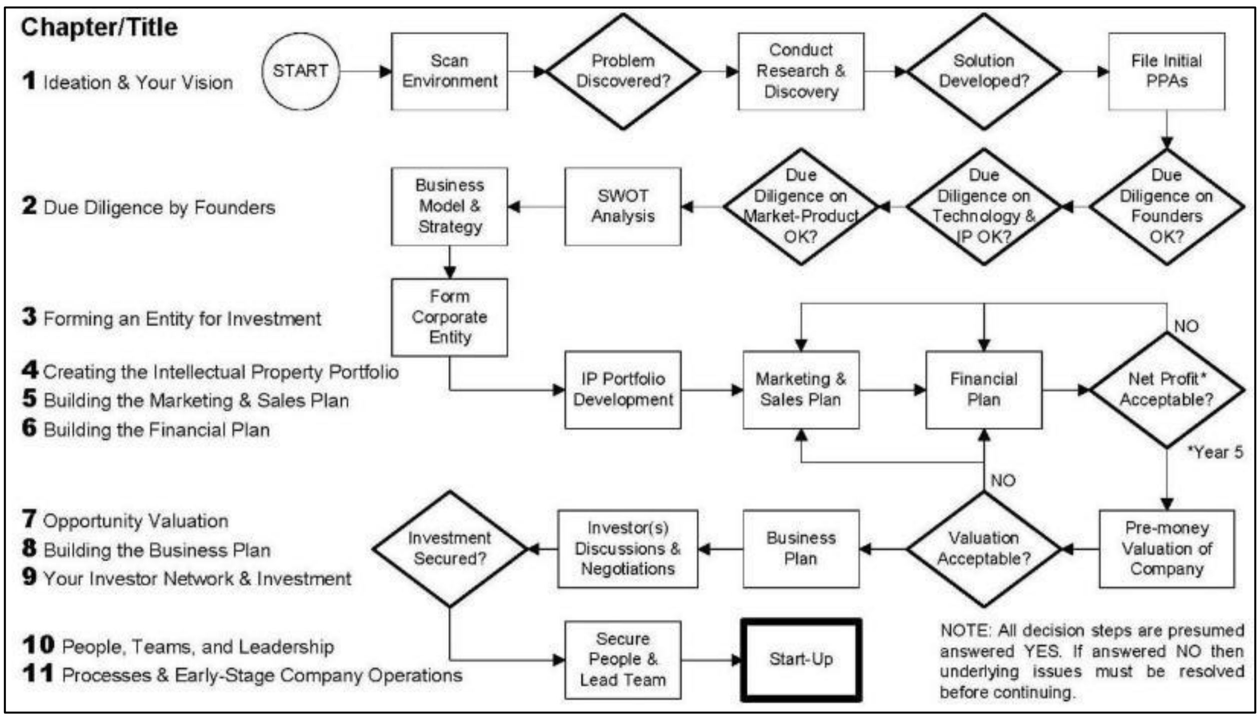
	Secured Loan	Unsecured Loan
Risk	Can be a significant risk for borrowers. If a business owner defaults on the loan, they could lose collateral such as personal property or assets that are essential for business operations.	Does not require collateral, which reduces personal and business risk in case of default.
Rates	Borrowers can qualify for lower interest rates than unsecured loans. Rates can be as low as 4%.	Rates are typically much higher than rates for secured loans.
Terms	Fewer fees and penalties, flexible terms, and easier repayment.	Often has stricter terms, higher fees, and penalties for early repayment.
Likelihood of qualifying	More stringent requirements, such as a good credit score, two years in business, and annual revenue more than $250,000, make it harder to qualify.	Can be easier to qualify for due to lower annual revenue requirements and no requisite collateral. Applicants need to have a good credit score and a strong business plan or a business in good financial standing.

Source: 2015 Magnify Money

Investors – Institutional, Family Offices, Venture Capital, Impact Investors, etc.

Investors are more willing to take on risk, but the cost is substantially higher than conventional loans. Venture capital is money provided by an outside investor to finance a new, growing, or troubled business. The venture capitalist provides the funding knowing the there is a significant risk associated with the company's future profits and cash flow, Capital is invested in exchange for an equity stake in the business rather than given as a loan. Venture Capital is the most suitable option for funding a costly capital source for companies and most for businesses having large upfront capital requirements which have no other cheap alternatives (2016 Aastha Chaudhary). Institutional investors, family offices and impact investors are all types of venture capital. Fifty percent financing may require the project developer to give up control of the project. Figure 22 shows the venture capital valuation process.

Figure 22: Venture Capital Valuation Process Flow Chart



Source: 2017 Cmerge.com

Government Guarantees – State and Federal

Prior to the Trump administration the USDA and USDOE were good sources of government guarantees for renewable energy conventional loan packages. There are four U.S. government loan guarantee programs that provide low-interest loans for renewable energy and energy efficiency projects.

Two of these programs—the US Department of Agriculture Loans (USDA's) Business & Industry (B&I) Loan Guarantee Program and Rural Energy for America Program (REAP)—provide funding for installing, using and deploying existing, commercially available technologies.

The B&I program also provides guarantees for a wide variety of other loans, including:

- Business conversion, enlargement, repair, modernization, or development;
- Purchase and development of land, easements, rights-of-way, buildings, or facilities;
- Purchase of equipment, leasehold improvements, machinery, supplies, or inventory;
- Debt refinancing when new jobs will be created, and other conditions are met; and
- Business and industrial acquisitions when the loan will keep the business from closing and/or save or create jobs.

The other two programs –USDA's Section 9003 Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program and the U.S. Department of Energy's (DOE's) Title XVII Innovative Clean Energy Loan Guarantee Program—are designed specifically for commercializing first-of-a-kind technologies.

Existing, Commercially Available Technologies

The USDA's B&I and REAP programs provide guarantees for loans from commercial lenders. The two advantages of these guarantees are they reduce risk for the lenders, hence, make the lenders much more willing to finance a project. The second advantage is that, because of the guarantee, lenders offer a lower interest rate, often 1 point or more below their normal commercial lending rate.

The guarantees cover loans up to $25 million per project. In some cases, it is possible to combine the B&I and REAP guarantees to cover a loan for a $50 million project.

First-of-a-Kind Technologies

For first-of-a-kind technologies, there are two choices:

· USDA's Section 9003 program provides guarantees for loans up to $250 million from commercial lenders. Applications are limited to the program's three areas of focus: biofuels, renewable chemicals and bioproduct manufacturing. In all cases, a certain amount of biofuel must be produced.

· DOE's Title XVII Loan Guarantee Program provides ultra-low-interest loans through the Federal Financing Bank (FFB), a branch of the U.S. Treasury, from commercial lenders or a combination of the two. DOE has close to $40 billion in funding authority and has financed several projects in the billions of dollars including a $8.5 billion advanced nuclear power facility and a $5.6 billion concentrated solar power facility. Loans guarantees are available for renewable energy, energy efficiency, advanced fossil energy, advanced nuclear energy, and advanced vehicle technology manufacturing projects. (Evans, 2017)

Bonds

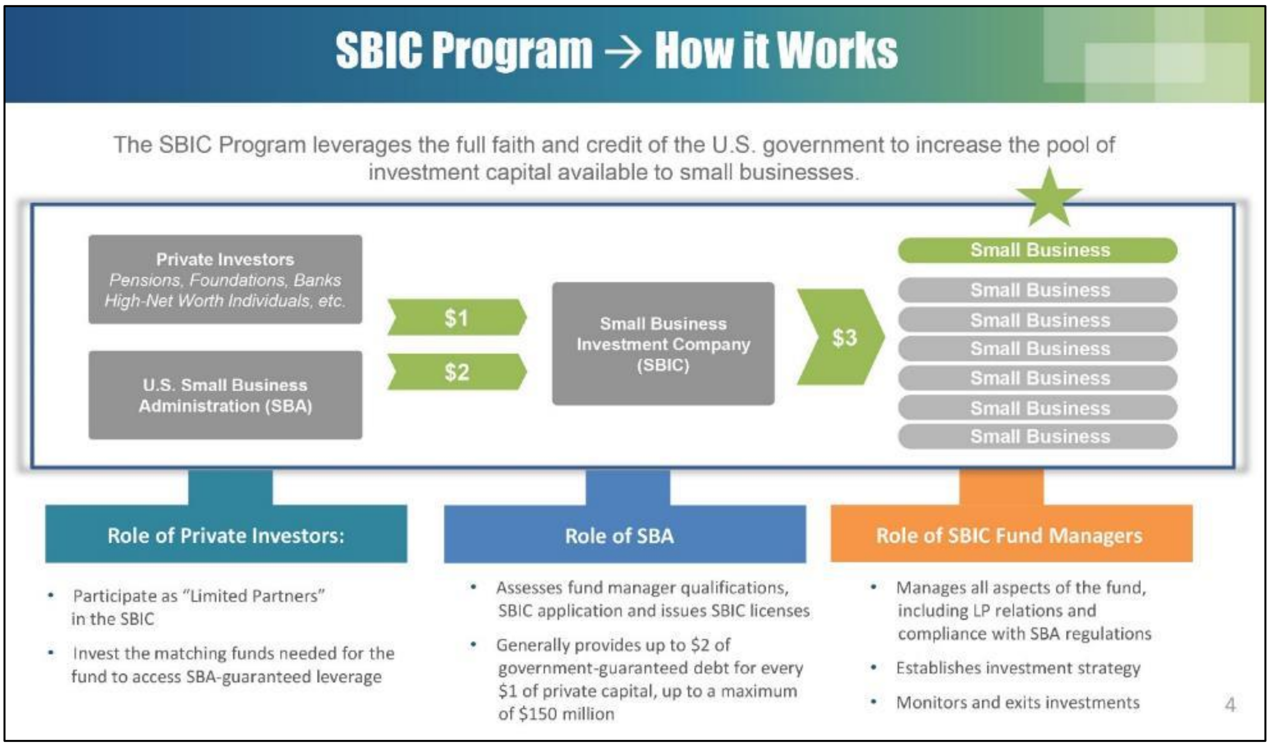
When companies or other entities need to raise money to finance new projects, maintain ongoing operations, or refinance existing debts, they may issue bonds directly to investors instead of obtaining loans from a bank. The indebted entity (issuer) issues a bond that contractually states the interest rate that will be paid and the time at which the loaned funds (bond principal) must be returned (maturity date). The interest rate, called the coupon rate or payment, is the return that bondholders earn for loaning their funds to the issuer. Convertible notes are issued by many corporations which allow a bond holder to convert the bond into equity at a fixed rate. (Investopedia, 2018)

For corporate bond issuance private placement, entities must compare the pros and cons to see what would be a better fit. Some benefits are the process may bypass some registration requirements, shorten the timeline to market, and lower cost. Some negative aspects are constraints on communication and marketing, restrictions on size, and investor qualification requirements may apply.

SBA Small Business Investment Company

The Small Business Administration has a special investment program called the Small Business Investment Company (SBIC), explained in Figure 23. The SBIC is set up to loan to small businesses (such as distributed renewable energy projects) and receives two investment dollars for every dollar of private equity investment.

Figure 23: Small Business Investment Company



Source: 2018 US Small Business Administration

Incentives and Subsidies

Self-Generation Incentive Program

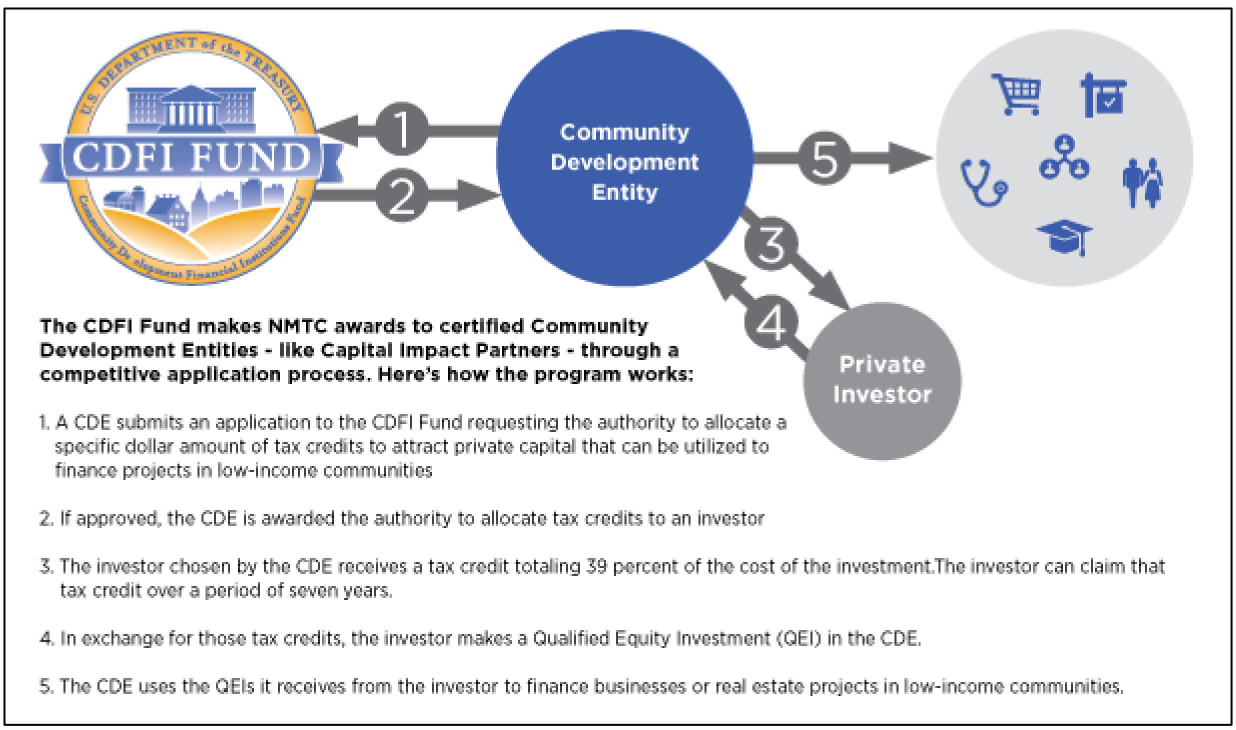
The Self-Generation Incentive Program (SGIP) provides financial incentives for the installation of new qualifying technologies that are installed to meet all, or a portion of the electric energy needs of a facility. The purpose of the SGIP is to contribute to Greenhouse Gas (GHG) emission reductions, demand reductions and reduced customer electricity purchases, resulting in the electric system reliability through improved transmission and distribution system utilization;

as well as market transformation for distributed energy resource (DER) technologies. (California Public Utilities Commission, 2017)

New Market Tax Credits

The New Markets Tax Credit Program (NMTC Program) helps economically distressed communities attract private capital by providing investors with a Federal tax credit, which is explained in Figure 24. Investments made through the NMTC Program are used to finance businesses, breathing new life into neglected, underserved low-income communities. Through the NMTC Program, the CDFI Fund allocates tax credit authority to Community Development Entities (CDEs) through a competitive application process. CDEs are financial intermediaries through which private capital flows from an investor to a qualified business located in a low-income community. CDEs use their authority to offer tax credits to investors in exchange for equity in the CDE. Using the capital from these equity investments, CDEs can make loans and investments to businesses operating in low-income communities on better rates and terms and more flexible features than the market.

Figure 24: New Market Tax Credits



Source: 2017 US Department of the Treasury

Renewable Identification Numbers and Renewable Energy Certificates

A Renewable Identification Number (or RIN) is a serial number assigned to a batch of biofuel for the purpose of tracking its production, use, and trading as required by the United States Environmental Protection Agency's Renewable Fuel Standard (RFS) implemented according to the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. (US EPA, 2018)

Renewable Energy Certificates (RECs), also known as Green tags, Renewable Energy Credits, Renewable Electricity Certificates, or Tradable Renewable Certificates, are tradable, non-tangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource (renewable electricity) and was fed into the shared system of power lines which transport energy. Solar renewable energy certificates (SRECs) are RECs that are specifically generated by solar energy. Renewable Energy Certificates provide a mechanism for the purchase of renewable energy that is added to and pulled from the electrical grid. The updated Greenhouse Gas Protocol Scope 2 Guidance Guarantees of Origin, RECs and I-RECs as mainstream in the United States, spot prices for SRECs generally decreased from 2010 to 2014. In New Jersey, the spot price for a 2010 SREC was $665.04 in July 2010 and about $160 in May 2014 for SRECs generated in different years. In Delaware, the spot price for a 2010 SREC was $255 in July 2010 and about $50 in May 2014 for SRECs generated in different years. Rates for 2015 to 2017 RECS purchased have averaged between $0.15—$0.045 per kWh produced. (US EPA, 2018)

Low Carbon Fuel Standards

The Low Carbon Fuel Standard (LCFS) is designed to encourage the use of cleaner low-carbon fuels in California, encourage the production of those fuels, and therefore, reduce greenhouse gas emissions. The LCFS standards are expressed in terms of the "carbon intensity" (CI) of gasoline and diesel fuel and their respective substitutes. The LCFS is performance-based and fuel-neutral, allowing the market to determine how the carbon intensity of California's transportation fuels will be reduced. This program is based on the principle that each fuel has "lifecycle" greenhouse gas emissions that include CO_2, N_2O, and other greenhouse gas contributors. This lifecycle assessment examines the greenhouse gas emissions associated with the production, transportation, and use of a given fuel. The lifecycle assessment includes direct emissions associated with producing, transporting, and using the fuels, as well as significant indirect effects on greenhouse gas emissions, such as changes in land use for some biofuels. Subjecting this lifecycle greenhouse gas rating to a declining standard for the transportation fuel pool in California would result in a decrease in the total lifecycle greenhouse gas emissions from fuels used in California. (California Air Resources Board, 2018)

LCFS is designed for biofuels and not for renewable electricity and heat, however, many of the forms of renewable energy generated at the Zero Net Energy Farm can be used interchangeable for transportation fuel or for renewable electricity/heat, but not for both at the same time.

Sales and Use Tax Exclusion

The California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) has a special program for Sales Tax Exclusion (STE) for renewable fuel and energy projects, although it is oversubscribed and underfunded. (California State Treasurer, 2018) To be eligible for the STE Program under AB199, the applicant must satisfy the definitions of “Project” and

"Recycled Resource feedstock" (RF). Evaluations of RF applicants are of net benefits tests in both fiscal and environment benefits.

Business Energy Investment Tax Credit

The federal Business Energy Investment Tax Credit (ITC) has been amended a number of times, most recently in December 2015. The Table 2 shows the value of the investment tax credit for each technology by year. The expiration date for solar technologies and wind is based on when construction begins. For all other technologies, the expiration date is based on when the system is placed in service (fully installed and being used for its intended purpose). (US DOE, 2018)

Table 2: Business Energy Investment Tax Credit

TECHNOLOGY	12/31/16	12/31/17	12/31/18	12/31/19	12/31/20	12/31/21	12/31/22	FUTURE YEARS
PV, Solar Water Heating, Solar Space Heating/Cooling, Solar Process Heat	30%	30%	30%	30%	26%	22%	10%	10%
Hybrid Solar Lighting, Fuel Cells, Small Wind	30%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Geothermal Heat Pumps, Microtubines, Combine Heat and Power Systems	10%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Geothermal Electric	10%	10%	10%	10%	10%	10%	10%	10%
Large Wind	30%	24%	18%	12%	N/A	N/A	N/A	N/A

Source: 2018 USDOE

Grants

California Energy Commission

California Energy Commission grants are funded from several sources and have different purposes; however, all grant solicitations can be found on http://www.energy.ca.gov/contracts/. The Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) is for transportation fuels and vehicles, http://www.energy.ca.gov/altfuels/. While the Electric Program Investment Charge (EPIC) provides funding for applied research and development, technology demonstration and deployment, and market facilitation for clean energy technologies and approaches for the benefit of ratepayers of Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company through a competitive grant solicitation process. Projects must address strategic objectives and funding initiatives as detailed in the appropriate EPIC Investment Plan, http://www.energy.ca.gov/research/epic/.

California Air Resources Board

California Air Resources Board Air Pollution Incentives, Grants and Credit Programs are listed on https://www.arb.ca.gov/ba/fininfo.htm. In September 2017, CARB received $135 million to reduce emissions from the agricultural sector from Assembly Bill (AB) 134 (Committee on Budget, Chapter 254, Statutes of 2017) and AB 109 (Ting, Chapter 249, Statutes of 2017). The bills provide funding for agricultural harvesting equipment, heavy-duty trucks, agricultural pump engines, tractors, and other equipment used in agricultural operations. CARB is in the process of developing the Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program Guidelines, which will outline CARB's recommendations for expending these funds. CARB staff will present and seek comment on the development of FARMER Program Guidelines at public workshops in early 2018.

https://arb.ca.gov/ag/agincentives/agincentives.htm

California Department of Food and Agriculture

CDFA's Dairy Digester Research and Development Program (DDRDP) provides financial assistance for the installation of dairy digesters in California, which will result in reduced greenhouse gas emissions. CDFA received $99 million from the Greenhouse Gas Reduction Fund in 2017 (AB 109 - Budget Act of 2017) for methane emissions reductions from dairy and livestock operations. CDFA plans to allocate between 65-80 percent of the funds as incentives to support digester projects on California dairy operations. Remainder of the funding appropriation will incentivize development of non-digester practices to reduce methane emissions through the Alternative Manure Management Program (AMMP). DDRDP is guided by the Statement of Principles (PDF) of the California-Federal Dairy Digester Working Group. The Working Group is a partnership of state, federal and local agencies with the common goal of identifying and removing barriers to the wide adoption of dairy digester systems in California. https://www.cdfa.ca.gov/oefi/ddrdp/index.html

GO-Biz

The GO-Biz was created by Governor Edmund G. Brown Jr. to serve as California's single point of contact for economic development and job creation efforts. GO-Biz offers a range of services to business owners including: attraction, retention and expansion services, site selection, permit assistance, regulation guidance, small business assistance, international trade development, assistance with state government, and much more. http://www.business.ca.gov/Programs

USDA / USDOE / USDOC / ExIm Bank / EB-5

US Department of Agriculture Rural Development forges partnerships with rural communities, funding projects that bring housing, community facilities, business guarantees, utilities and other services to rural America. USDA provides technical assistance and financial backing for rural businesses and cooperatives to create quality jobs in rural areas. Rural Development promotes the President's National Energy Policy and ultimately the nation's energy security by engaging the entrepreneurial spirit of rural America in the development of renewable energy and energy efficiency improvements. Rural Development works with low-income individuals, State, local and Indian tribal governments, as well as private and nonprofit organizations and user-owned cooperatives. https://www.rd.usda.gov/programs-services/all-programs

US Department of Energy supports a number of grant, loan and financing programs. Learn more about these programs and how they can help – ranging from a startup energy business looking to launch a pilot project, a company with proven technology that needs help reaching commercial scale, or a state, local or tribal government looking for funding resources for energy projects. https://energy.gov/energy-economy/funding-financing

US Department of Commerce Economic Development Administration's investment policy is designed to establish a foundation for sustainable job growth and the building of durable regional economies throughout the United States. This foundation builds upon two key economic drivers - innovation and regional collaboration. Innovation is key to global competitiveness, new and better jobs, a resilient economy, and the attainment of national economic goals. Regional collaboration is essential for economic recovery because regions are the centers of competition in the new global economy and those that work together to leverage resources and use their strengths to overcome weaknesses will fare better than those that do not. EDA encourages its partners around the country to develop initiatives that advance new ideas and creative approaches to address rapidly evolving economic conditions. https://www.eda.gov/about/index.htm

US Export Import Bank has temporarily ceased operations due to the government-wide lapse in funding. EXIM has provided a Plan for Orderly Termination of EXIM Bank Operations in the Event of Failure to Enact Regular Appropriations or a Continuing Resolution document with more comprehensive information. Certain operations are required to continue even under a lapse in funding which are outlined in that document. Customers needing any forms and documents related to these continuing operations may find them in the list below. https://www.exim.gov/

EB-5 programs are administered by US Citizenship and Immigration Service which may provide funding for job creation resulting from the ZNEF program. Under EB-5, entrepreneurs (and their spouses and unmarried children under 21) are eligible to apply for a green card (permanent residence) if they: make the necessary investment in a commercial enterprise in the United States; and plan to create or preserve 10 permanent full-time jobs for qualified U.S. workers. This program is known as EB-5 for the name of the employment-based fifth preference visa that participants receive. Congress created the EB-5 Program in 1990 to stimulate the U.S. economy through job creation and capital investment by foreign investors. In 1992, Congress created the Immigrant Investor Program, also known as the Regional Center Program. This sets aside EB-5 visas for participants who invest in commercial enterprises associated with regional centers approved by USCIS based on proposals for promoting economic growth. https://www.uscis.gov/eb-5

Business Model Pro Formas

Expenses

Capital Expenditures

Capital Expenditures (CapEx) Capital are funds used by a company to acquire, upgrade, and maintain physical assets such as property, industrial buildings, or equipment. CapEx is often used to undertake new projects or investments by the firm. This type of financial outlay is also made by companies to maintain or increase the scope of their operations. Capital expenditures can include everything from repairing a roof to building, to purchasing a piece of equipment, or building a new factory. In the case of ZNEF it would include the renewable energy equipment hardware and installation. (Jan R. Williams, 2008)

Operating Expense

Operating Expenses (OpEx) are expenses a business incurs through its normal business operations. OpEx include rent, equipment, inventory costs, marketing, payroll, insurance and funds allocated toward research and development. One of the typical responsibilities that management must contend with is determining how low operating expenses can be reduced without significantly affecting a firm's ability to compete with its competitors. (Jan R. Williams, 2008)

Revenues

Offsetting Retail Rates, Tariffs

Farmers are already spending money for electricity and heat, defined by tariffs approved by the CA Public Utilities Commission. A tariff is a pricing schedule or rate plan that utilities offer to customers. Along with the pricing plan, there may be certain rules for each tariff a utility offers, such as the times or seasons when prices will vary, eligibility for a tariff, when/how a customer can join or leave the tariff, what type of meter must be installed and more. Other things that can be found in a utility's tariff book include sample forms that customers may be required to fill out, rules for applications for service, bill adjustment, low-income programs and service area maps. Tariffs are governed by CPUC General Order 96-B which lists all information that utilities are required to provide in their tariff books. A utility must have CPUC approval before changing any of its tariffs. Before any changes, a utility must file an advice letter, which is then reviewed by the CPUC. http://www.cpuc.ca.gov/General.aspx?id=12189

Displacing energy charges paid by farmers results in increased savings to farmers under the ZNEF program and can be counted as revenues to calculate Return on Investment.

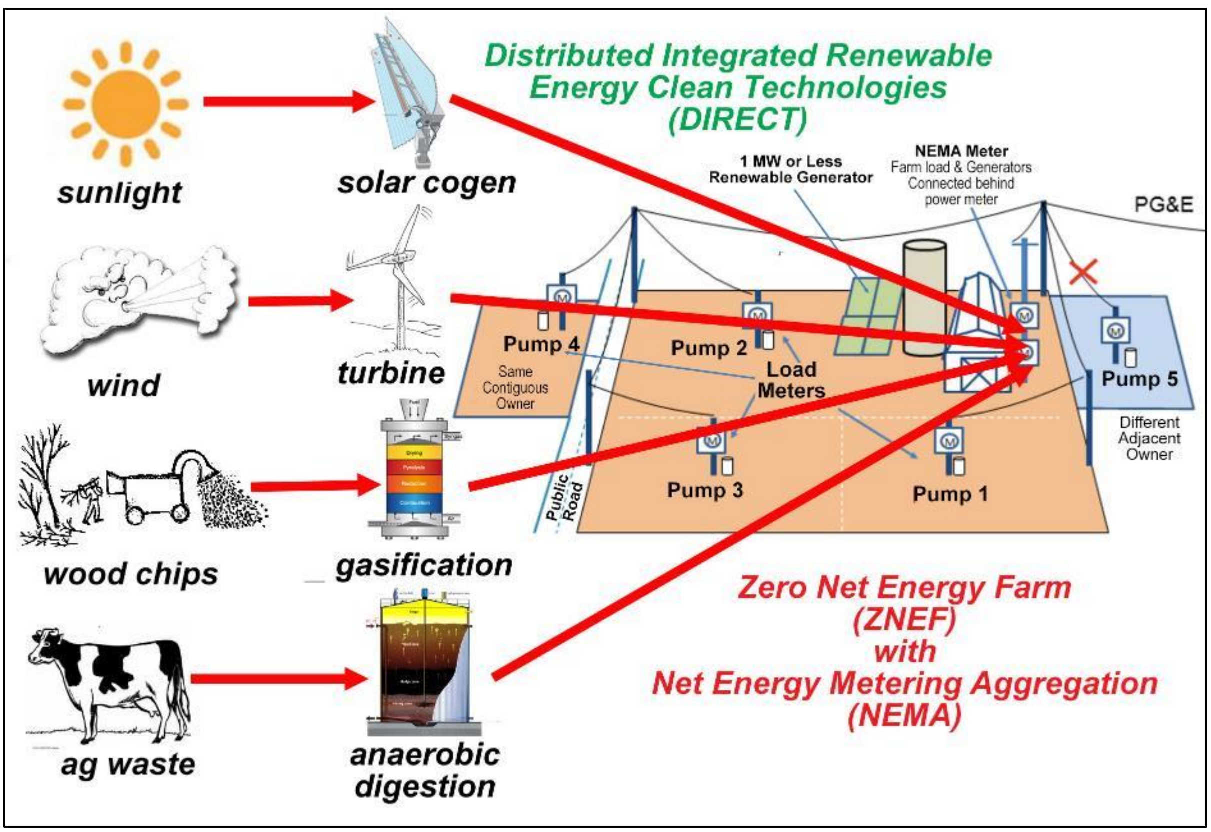
Net Energy Metering

Farmers that install small solar, wind, biogas, and fuel cell generation facilities to serve all or a portion of onsite electricity needs are eligible for the state's net metering program. NEM allows customers who generate their own energy ("customer-generators") to serve their energy needs directly onsite and to receive a financial credit on their electric bills for any surplus energy fed back to their utility. Participation in the NEM does not limit a customer-generator's eligibility for any other rebate, incentive, or credit provided by an electric utility. More than 90 percent of all megawatts (MW) of customer-sited solar capacity interconnected to the grid in the three-large investor-owned (IOU) territories (PG&E, SCE, and SDG&E) in California are on NEM tariffs. The program provides customer-generators full retail rate credits for energy exported to the grid and requires them to pay a few charges that align NEM customer costs more closely with non-NEM customer costs. If a customer-generator is not already on one, they will be required to take service on a TOU rate to participate in NEM. http://www.cpuc.ca.gov/general.aspx?id=3800

Net Energy Metering Aggregation

Senate Bill (SB) 594 (Wolk, 2012) authorized NEM aggregation (NEMA). NEMA allows an eligible customer-generator to aggregate the electrical load from multiple meters, and NEM credits are shared among all property that is attached, adjacent, or contiguous to the generation facility, shown in Figure 25. A customer-generator must be the sole owner, lessee, or renter of the properties in order to utilize NEMA. For example, an agricultural customer could use a single renewable generation system to provide NEMA bill credit to offset the electrical load from their home as well as from an irrigation pump located on an adjacent parcel. As of December 31, 2016, roughly 5 percent of all NEM projects were NEMA projects. http://www.cpuc.ca.gov/general.aspx?id=3800

Figure 25: Net Energy Metering Aggregation (NEMA) Diagram



Source: 2018 Biodico

StorageVET

Storage Value Estimation Tool (StorageVET®) is a publicly available, web-hosted, energy storage simulation tool developed by the Electric Power Research Institute (EPRI) with funding support from the California Energy Commission. StorageVET® provides a publicly available tool and method to fairly, transparently, and consistently estimate the benefits and costs of energy storage projects across all cases. https://www.storagevet.com/

StorageVet® was used to model revenues smart battery storage in ZNEF. The results are set forth in and references APPENDIX N: StorageVET Readouts.

Virtual Power Plant Sales to California ISO /IOU

ZNEF aggregates the DER components as a Virtual Power Plant (VPP) to serve microgrid participants and respond to automated dispatch requests from the CA Independent System Operator (CAISO) and the Investor Owned Utility (IOU) for the area, Pacific Gas and Electric (PG&E). The Nuvve Aggregation Platform (NAP) is the gateway between the distributed energy resource components and the California ISO /IOUs. NAP integrates demand response alongside distributed generation and energy storage to form a Virtual Power Plant with demonstrable economic value. Nuvve technology will automatically respond to California ISO and PG&E dispatch requests for demand, TOU and frequency response.

Demand response providers with the ability to aggregate customers capable of reducing their electric demand (load) can participate in the California ISO day-ahead, real-time and ancillary services markets. Demand-side resources can offer bids that reflect their flexibility to adjust their load in response to market schedules and dispatches. Metering and telemetry are mandatory tools for ensuring accurate revenue accounting and ISO operational visibility. California ISO market rules allow DER Aggregations (DERAs) to participate in the ISO market to provide energy and ancillary services. California ISO recognizes a Distributed Energy Resource Provider (DERP) as a new type of market participant that owns or operates DER with the ability to meet participation requirements, in aggregate, as a new type of market resource capable of operating in response to an California ISO schedule, award or dispatch. DERAs can participate in the California ISO day-ahead, real-time and ancillary services markets as a participating generator using participation models that fit the needs of the DERA. California ISO envisions these resources contributing to the low-carbon, flexible capacity needed to maintain real-time system balance and reliability supporting the integration of renewable energy.

Individual DERs within an aggregation must have a rated capacity less than 1 MW. The rated capacity of a DERA will be no smaller than 0.5 MW and no larger than 20 MW. As with other California ISOagreements, the DERP Agreement (DERPA) will bind the DERP to the California ISO Tariff. The DERPA, among other things, also requires that the DERP satisfy all applicable rules and regulations of the Utility Distribution Company (UDC) / Metered Sub System (MSS) as well as requirements of the applicable Local Regulatory Authority (LRA). The agreement requires that the DERP use a certified Scheduling Coordinator (SC) certified to submit Settlement Quality Meter Data (SQMD) and have a Meter Service Agreement for Scheduling Coordinators (MSASC) with the California ISO for all tariff activities with the California ISO. The DERPA requires that the DERP obtain concurrence from the applicable UDC/MSS that there are no concerns with any DERA's wholesale market participation. Additionally, the SC for a DERP must have the authority to represent Scheduling Coordinator Metered Entities (SCME). The SC for a SCME is responsible for providing SQMD for the DERPAs it represents. The SC for SCME must conduct (or engage an independent, qualified entity to conduct) an annual SC Self-Audit.

The following is a rough outline of the California ISO to DER pathway:

Distributed Energy Resource (DER) - Any resource with a first point of interconnection to a Utility Distribution Company (UDC) or a Metered Subsystem (MSS).

Distributed Energy Resource Aggregation (DERA) - A resource comprised of one or more DER.
Distributed Energy Resource Provider (DERP) - The owner/operator of one or more Distributed Energy Resource Aggregations that participates in the California ISO markets.
Distributed Energy Resource Provider Agreement (DERPA) - An agreement between the California ISO and a DERP that includes a tariff agreement.
Scheduling Coordinator Assignment – Assess Market Participation System Access Needs and Market Participation Training Needs.
UDC/MSS coordination of DERA development - Concurrence Letter Obtained.
New Resource Implementation - Project Details Form and Resource ID obtained.

CAISO Automated Dispatch System

The proposed project will take advantage of new markets opening up especially at California ISO , and by the final year of the grant contract, the project's value will have been increased due to more opportunities for grid services provided by mixed DER aggregations.

Nuvve intends to utilize the services of Customized Energy Solutions ("CES") to assist with scheduling and settlement services for multiple California-based distributed electric storage systems. The services will enable communications between the storage systems and California ISO via one common "cloud" connection for all resources and enable participation of the resources in California ISO 's regulation market. Nuvve currently has established an engagement with CES to provide such grid services in the PJM region (Pennsylvania, New Jersey and Maryland).

Additional resources added during this project may require a change to the tariff that allows a higher generation capacity considering the size of the grid connection. Biodico will optimize the use of the new and existing resources via the current grid connection, considering planned changes in PG&E's rate structure over the next few years, and determine the California ISO services that are accessible as a microgrid entity aggregating with external resources.

Revenue options include but are not limited to: PG&E Seasonal Capacity Bidding Program (May-Oct); PG&E Demand Response Auction Mechanism (DRAM) (modeled participation to prepare to bid as it moves for pilot to a full-scale program), and; California ISO Frequency Response; California ISO Flexible Ramping Product; California ISO Spinning Reserve.

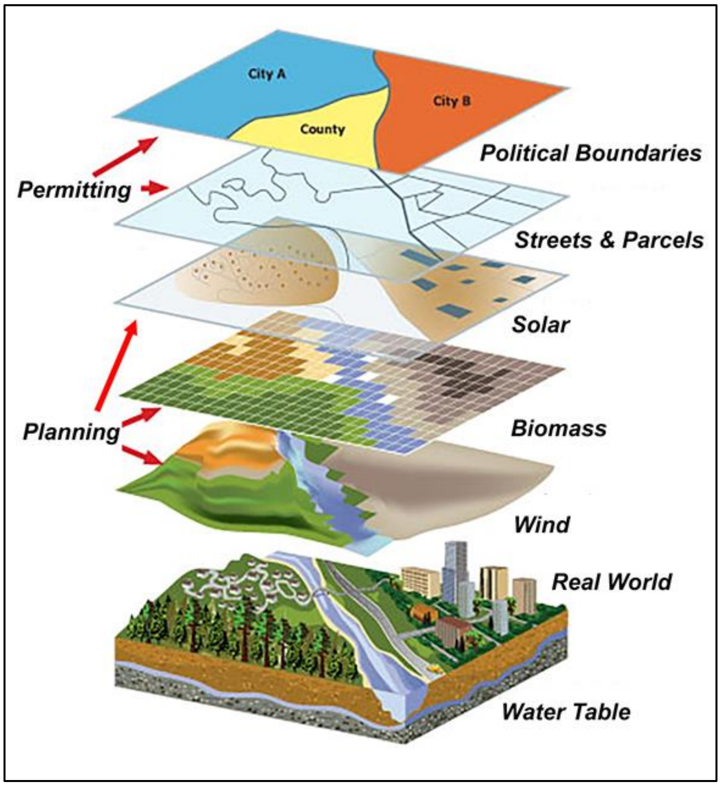
Installations may be subject to demand charges, which can be managed, or EV-TOU/other TOU rate schedules that will be considered as operating parameters. Nuvve will layer revenue streams from wholesale services within the regulatory confines of the California ISO/IOU programs to develop an optimized suite of services and a strategy for deployment.

CHAPTER 2: Program Management Application – Bring Together the Four Elements into a Usable Format

Project Manager and Optimizer

There is no independent resource available for the agricultural community to determine the optimal combination of technologies when installing individual DERs or a full microgrid. The goal of Biodico's ZNEF Geoplanner is to fill that need. The ZNEF GeoPlanner is a web-based tool that utilizes solar, wind and biomass data, geographically overlaid on a map of California. It is designed expressly for the integration of renewable energy into IOU electric grids by estimating location-specific energy generation for the following distributed energy resources (DERs): solar, anaerobic digestion, gasification and/or wind turbine energy generation technologies. Each of the proposed renewable energy technology combinations has its own specific limitations. Solar is limited by a diurnal cycle, anaerobic digestion is limited by the need to sustain biological processes, wind turbines are limited by convection, and gasification technology is limited to feedstock availability. This approach is integrated into the software developed through this project and will be critical to replicability for future projects, illustrated in Figure 26.

Figure 26: Example of Data Layering in GeoPlanner



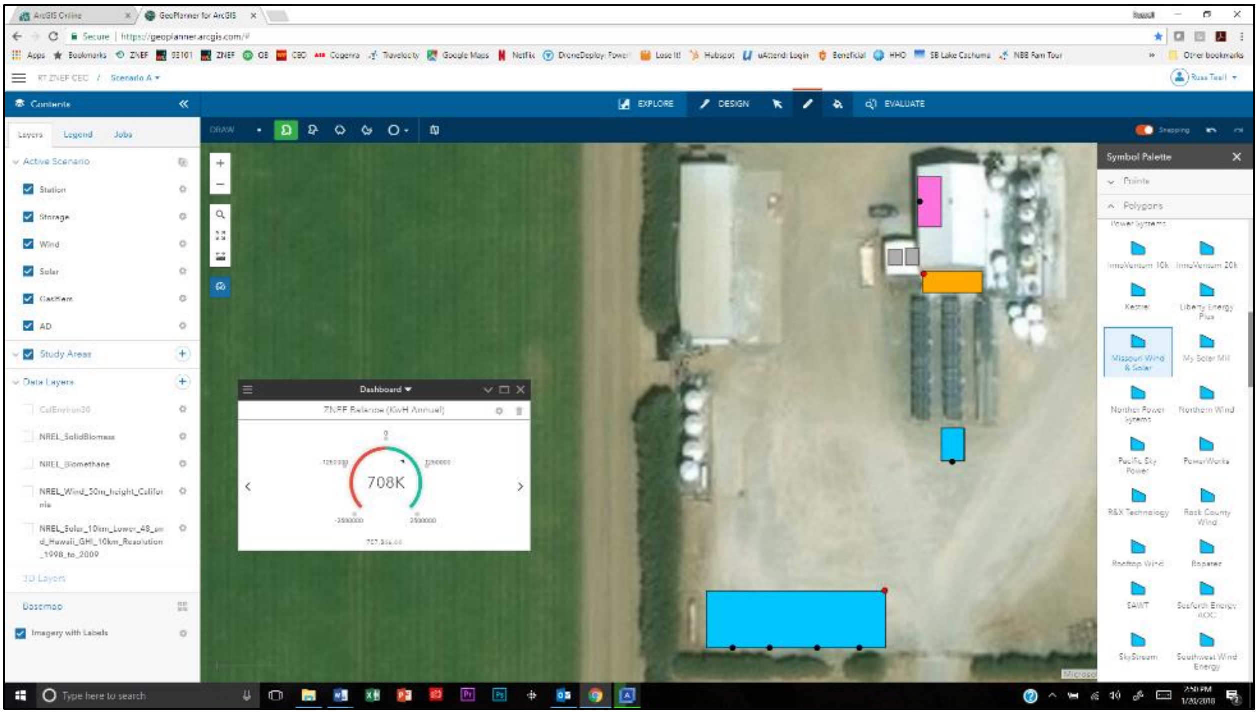
Source: 2107 Biodico and ESRI

The ZNEF GeoPlanner also helps identify planning, permitting and financing requirements that can slow the implementation process. Using this information, Biodico assembled the resources needed and develop fast track guidelines to facilitate this project and incorporate them into ZNEF GeoPlanner. ZNEF GeoPlanner also incorporates data from contractor sourcing, financing for future projects, as well as existing guidelines, such as those provided by NREL. This process fast tracks implementation and eases the financial burden on the companies involved. It also improves the ability of local government entities and private companies to commercialize and integrate renewable technologies into existing IOU grids.

ZNEF GeoPlanner optimizes, or down-selects, the various energy generation technologies and/or planning, permitting, and financing options for a given Zero Net Energy Farm. It does this by (1) performing a resource assessment for solar, wind and biomass energy potential, (2) referring to a library of distributed renewable energy technologies, for example, numerous vendors for solar panels, wind turbines, gasifiers and anaerobic digesters, (3) taking inputs for the types of energy use on a particular property, for example to total kWh consumed, the time of use, demand charges and the tariff, and (4) optimizing available resources and their corresponding technologies to meet the energy needs of the property with the most economical solution for the area available. ZNEF GeoPlanner also includes boundary maps for the various California Air Districts as well as available financing options, incentives and subsides as seen in Figure 27. Overall, it gives clients, without the specific knowledge of renewable energy, the tools to decide which combination of technologies to use while giving them a better understanding of the costs and local resources needed to make the project feasible.

It is important to note that the ZNEF GeoPlanner is only available to licensed users and that due to its complexity, a potential user of the ZNEF GeoPlanner would need assistance from Biodico and ESRI to act as a facilitator, consultant and guide for using the ZNEF GeoPlanner.

Figure 27: Zero Net Energy Farm GeoPlanner Screenshot



Source: 2018 Biodico and ESRI

ZNEF GeoPlanner will be essential for identifying key strategic points for aggregation to the grid. First it must be determined which properties can be aggregated under PG&E's NEMA program. These are generally contiguous properties under common ownership or control. The 1,300-acre portion of Red Rock Ranch identified for this proposal meets these requirements for aggregation. The optimal location within an aggregated agricultural property will be where (1) the greatest number of renewable energy resources are located, and (2) the highest wattage meter is located to minimize interconnection charges. By taking advantage of ZNEF GeoPlanner the project developer will have the ability to identify the appropriate technology for the optimal location based on the geography, weather or feedstock requirements.

Creating ZNEF GeoPlanner

GeoPlanner for ArcGIS is an ESRI created application for informed, evidence and performance-based planning and design. It provides a design framework and supporting technology for professionals to leverage geographic information, resulting in designs that more closely follow natural systems. GeoPlanner is a collaborative tool—it can work simultaneously with others on plans and designs or share items including web maps, feature layers, and data exports. For example, Biodico could work collaboratively with the Energy Commission to further develop the ZNEF GeoPlanner to include transmission line for utility grade solar PV planning.

GeoPlanner supports a complete planning workflow from project creation to report generation. The workflow is implemented across different segments within the application. GeoPlanner concepts including immediate feedback, collaborative decision making, and assessing site performance and conditions influence all parts of the workflow. The following sections provide an overview of working with the application.

Project

The first step in GeoPlanner is to create a project from a template. Templates (and projects) contain a web map and a scenario layer that have the symbols and attributes used for drawing, painting and computing key performance indicators. Custom templates can be created to meet the specific needs. A shared project area can be designed, and other users can be invited to collaborate.

Explore

GeoPlanner allows use of shared GIS datasets on ArcGIS Online to be added to a project. Proprietary data or ESRI-provided content can be added, including landscape data. Assessments in dashboards help in understanding how designs interact with a site.

Design

GeoPlanner allows multiple alternative design scenarios. Dashboards help visualize suitability and probable impacts by comparing designs to assessments. Imported features into a scenario to help understanding existing conditions. Scenarios are shared with all invited users in a project, so a project team has access to all designs.

Evaluate

GeoPlanner has comparison and evaluation tools to help visualize a design's impact. Scenarios can be compared side–by–side to see how alternative planning scenarios and their impacts differ. In this mode, dashboards help clarify qualitative and quantitative differences. A Key Performance Indicator (KPI) report allows all indicators across one or more scenarios to be viewed.

Share

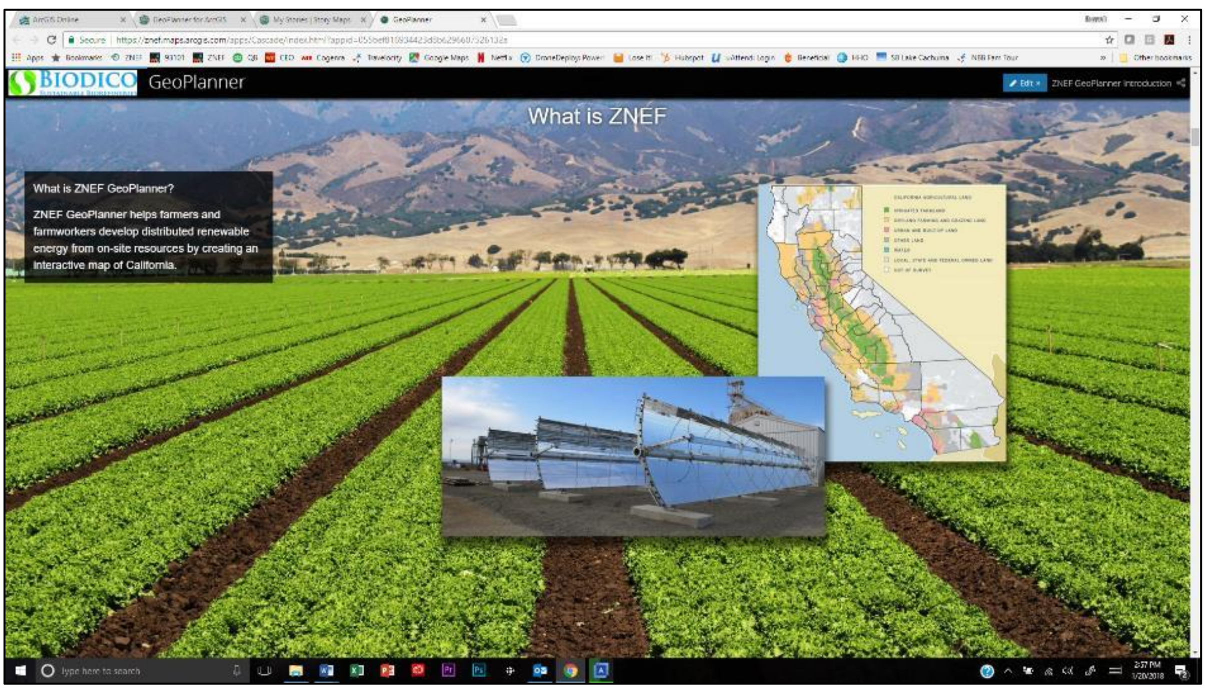
GeoPlanner helps to share data and collaborate with other stakeholders. This helps to validate design decisions with others. Sharing can include data, projects, dashboards, web maps and more. Nearly everything created in GeoPlanner can be used across the ArcGIS Platform.

Story Map

ESRI Story Maps combines authoritative maps with narrative text, images, and multimedia content, an example in Figure 28 and Figure 29. They make it easy to harness the power of maps and geography to tell a story. Story Map application templates come in a variety of flavors. Choose an app with a user experience appropriate for the story. The Story Map Tour, for instance, is great for sets of places with photos and short captions. For longer text, the Story Map Journal might be better. For a comparison of different maps, the Story Map Series makes the most sense. For a long, less structured narrative that people read like a web page, use the Story Map Cascade. See the Story Map Apps page to get started and to compare the available apps. https://storymaps.arcgis.com/en/

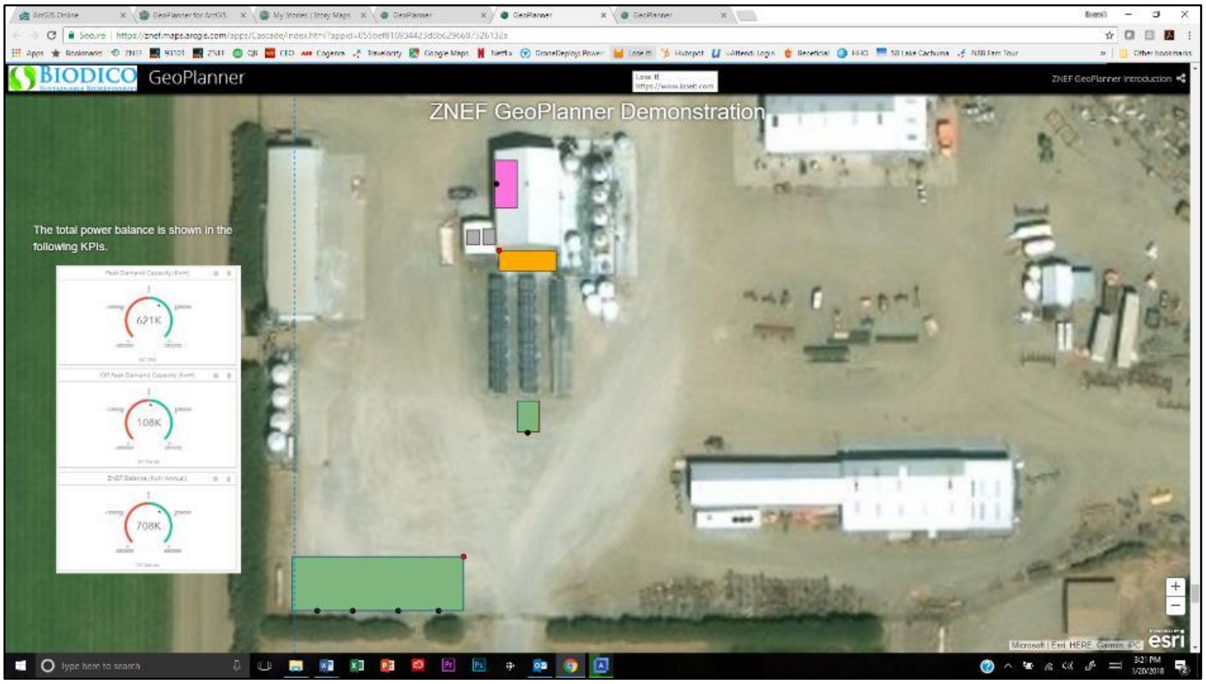
A Story Map was created as an introduction and overview of the capabilities of the ZNEF GeoPlanner, as discussed in APPENDIX Q: Project Management Application Report. A link to the ZNEF GeoPlanner Story Map is as follows: https://znef.maps.arcgis.com/apps/Cascade/index.html?appid=055bef816934423d8b6296607526132a

Figure 28: Story Map Created for Zero Net Energy Farm GeoPlanner



Source: 2018 Biodico and ESRI

Figure 29: Story Map Showing GeoPlanner Design and Key Performance Indicator for Red Rock Ranch



Source: 2018 Biodico and ESRI

CHAPTER 3: Master Community Design

Twelve Components

The proposed Zero Net Energy Farm (ZNEF) Master Community Design (MCD) integrates five types of Distributed Energy Resources (DER) into a microgrid in a disadvantaged community with a CalEnviroScreen 3.0 score of 81.51 percent. The MCD aggregates the DER components as a Virtual Power Plant (VPP) to serve microgrid participants and respond to dispatch requests from the California Independent System Operator (CAISO) and the Investor Owned Utility (IOU) for the area, Pacific Gas and Electric (PG&E).

The goals and objectives of this Master Community Design are to:

1. Use renewable resources, energy efficiency, smart batteries and Vehicle-to-Grid (V2G) technology to create a VPP.
2. Ensure viable metering and telemetry for dispatch with California ISO /IOU.
3. Reduce costs and increase reliability of electric service to ratepayers and California ISO /IOU.
4. Create meaningful local jobs and economic development in disadvantaged communities.
5. Improve the air quality of the Central Valley; reduce criteria air pollutants, air toxins and greenhouse gases (GHGs).
6. Demonstrate viability for similarly situated agricultural interests and communities.

The Five Types of Distributed Energy Resources

Distributed Energy Resources are defined in the California Public Utilities Code as renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies.[1] The five types of DER in the MCD are listed below. The specific components of each DER type are listed in parentheses and described in ***Error! Reference source not found.***.

1. Distributed renewable generation resources (Tractor Ports, CoolPV Awning, Giraffe 2.0, Smart Flower, Froling Gasifier, Entrade E3 Gasifier, Smart Street Lamps)
2. Energy efficiency (Community Energy Efficiency)
3. Energy storage (Smart Batteries, Smart Street Lamps, Community Energy Efficiency)
4. Electric vehicles (Nuvve V2G)
5. Demand response technologies (Nuvve Aggregation Platform)

In total, this comes to twelve specific DER components that will be used in this Master Community Design.

1 California Public Utilities Code section 769(a) (California Legislative Information, 2018), AB 327, Sec. 8, Perea, 2013 (California Legislative Information, 2018)

Twelve Distributed Energy Components

Brief definitions of each DER component can be found below. More detailed explanations can be found in Appendices referenced in the links shown after each component.

1. **Tractor Port –** This is a larger version of a car port capable of storing agricultural equipment and combining rooftop solar photo voltaic (PV) panels and wind turbines. Wind resources are marginal in this area and turbines pose a hazard to birds. By using the Tractor Port as a wind scoop, wind resources can be magnified, and shielded turbines can be mounted at ground level to protect birds. *APPENDIX A: Tractor Port*
2. **CoolPV Awnings –** These are composed of a traditional solar PV panel backed by a water jacket so the panel produces both electricity and heat. *APPENDIX B: CoolPV*
3. **Giraffe 2.0 –** This combines solar PV and wind to charge electric vehicles (EV) in an award winning wooden structure that sequesters more carbon than a steel equivalent structure (Sneed, 2017) (Bellassen, 2014; Sneed, 2017).[2] *APPENDIX C: Giraffe 2.0*
4. **SmartFlowers –** These are PV panels mounted on a dual axis system that tracks the sun and folds up at night and in high winds. When it unfolds it cleans the solar panels which can be degraded from optimal performance, up to 26 percent, due to dust accumulation (Hai, 2011).[3] It is also a self-contained level 2 EV charging station. *APPENDIX D: SmartFlowers*
5. **Froling T4 Wood Chip Boiler –** This generates energy using wood waste from orchards and vineyards that would otherwise go to waste. Previously it would have been used by the biomass energy facilities in the Central Valley, but those have closed. This already available resources (wood waste) to use by, burning it to generate energy but on a smaller scale than the large facilities previously operating in the area. It is highly efficient and surpasses all applicable emission standards (TUV Austria). *APPENDIX E: Froling T4 Wood Chip Boiler*
6. **Entrade E3-E4 Gasifier –** This produces heat and power using pellets made from wood waste from orchards and vineyards. As opposed to the boiler, this technology provides combined heat and power (CHP), but is more complex. It is "on demand" CHP to balance intermittent sources. *APPENDIX F: Entrade E3-E4 Gasifier*

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[2] Bellassen, Valentin, Sebastiaan Luyssaert., Nature, Managing Forests in Uncertain Times, February 13, 2014, Volume 506, Page 153, "Trees absorb carbon dioxide from the atmosphere, and wood can be a substitute for fossil fuels and carbon-intensive materials such as concrete and steel. In the past few decades, the world's forests have absorbed as much as 30 percent (2 petagrams of carbon per year; Pg C year–1) of annual global anthropogenic CO2 emissions — about the same amount as the oceans."

[3] Hai, Jiang, Lin Lu, Ke Sun. Experimental investigation of the impact of airborne dust deposition on the performance of solar photovoltaic (PV) modules, Atmospheric Environment, Volume 45, Issue 25, August 2011, Pages 4299-4304

7. **Expanded Granular Sludge Bed (EGSB) Anaerobic Digester –** It has an accelerated hydraulic retention time compared to conventional anaerobic digesters (1-day vs. 20-45 days) and maximizes the organic loading rate (close to 100 percent) and volatiles destruction (90 percent). It uses agricultural waste as a substrate. *APPENDIX G: Expanded Granule Sludge Bed Anaerobic Digestion*
8. **Smart Batteries –** Distributed Renewable Generation (DRG) will be used to charge smart batteries (stand-alone banks and in EVs) which will discharge to reduce demand spikes, optimize time of use (TOU) and respond to California ISO /IOU as a VPP controlled by Nuvve. Smart batteries will also be deployed in 50 locations at Red Rock Ranch as part of the Community Energy Efficiency program. Green Raiteros[4] Independent Transportation (GRIT) electric vehicles (EVs), as well as employee and visitor EVs will provide additional smart battery capacity, though the vehicles cannot be EPIC grant funded. *APPENDIX H: Smart Batteries*
9. **Smart Street Lamps / Smart Farm –** 50 solar/wind powered LED street lamps will provide lighting, battery storage, USB charging, WiFi communication and power management signals throughout the VPP. These will be built, installed and maintained by a local ZNEF workforce hired and trained for this project. (California Environmental Protection Agency, 2018) *APPENDIX I: Smart Lamp / Smart Farm*
10. **Community Energy Efficiency –** The ZNEF workforce will also provide attic LED lights, smart thermostats, smart batteries, and smart electric outlets to 50 locations at Red Rock Ranch. These will be integrated with centralized control as part of Nuvve's VPP to enable automatic response to California ISO and PG&E. *APPENDIX J: Community Energy Efficiency*
11. **Nuvve Vehicle to Grid (V2G)** - V2G charging will be utilized to take advantage of EV batteries in the GRIT vehicles mentioned in the above Smart Batteries section, as well as the EVs of other residents and visitors when they are parked at the Zero Net Energy Farm. *APPENDIX K: Nuvve Vehicle to Grid*
12. **Nuvve Aggregation Platform (NAP) –** is the gateway between the twelve DER components and the California ISO /IOUs. NAP integrates demand response alongside distributed generation and energy storage to form a Virtual Power Plant (VPP) approach, creating demonstrable economic value. Nuvve technology will automatically respond to California ISO and PG&E dispatch requests for demand, TOU and frequency response. *APPENDIX L: Nuvve Aggregation Platform*

Table 3 shows the Installed Capacity and Actual Capacity of the individual Components that comprise the ZNEF project. The installed capacity can vary significantly from the actual capacity for intermittent sources of renewable energy. For example, solar and wind are not generating power when the sun doesn't shine or the wind doesn't blow. The National Renewable Energy Laboratory (NREL) System Advisory Model (SAM) calculates the Capacity Factor based on the characteristics of the equipment and its location. For the ZNEF the

[4] Raiteros are the drivers and passengers of a Mexican culture form of ride sharing.

projected capacity is 2,149 kW, with an expected annual generation of 15,393 MWh

Table 3: Zero Net Energy Farm Component Capacity

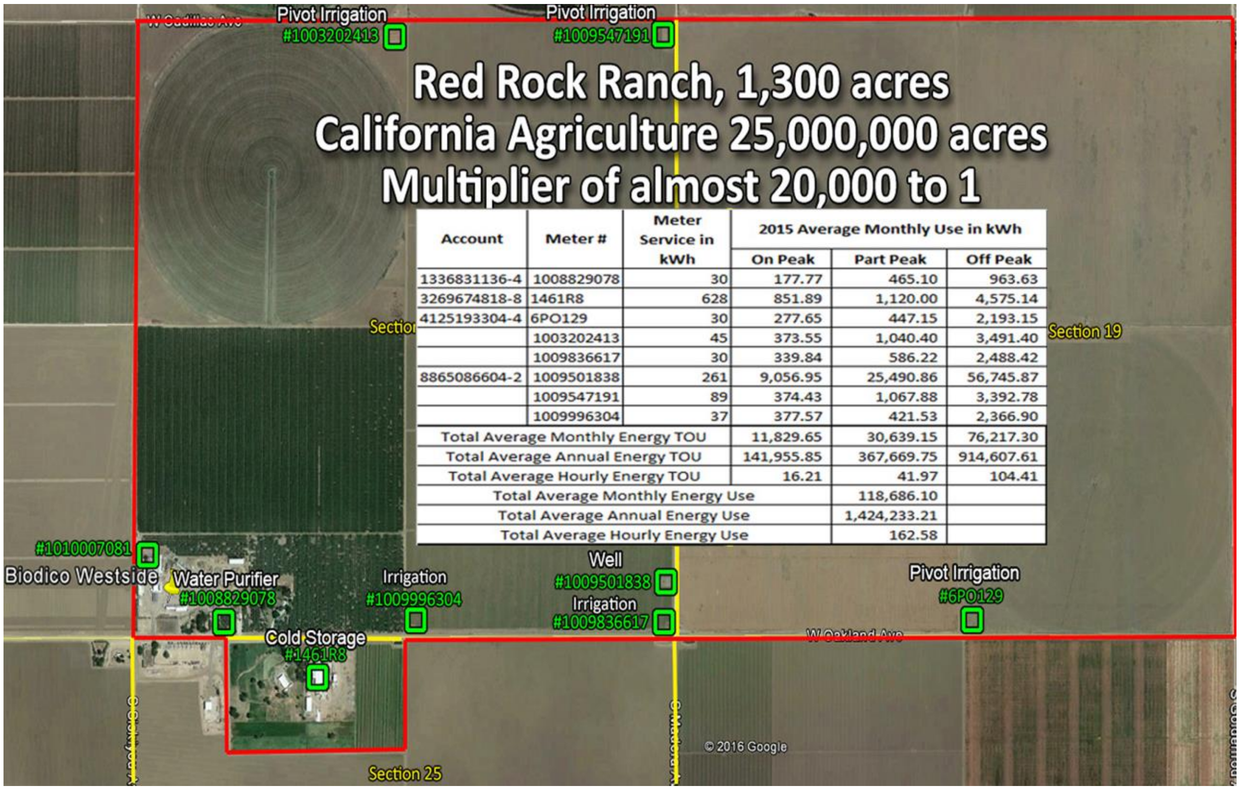
Zero Net Energy Farm Component Capacity		Installed Capacity		Projected Actual Capacity					
Components & Number of Units In Parentheses		Displaced Electric Heat	Power	Energy Efficiency	Battery	Solar (NREL PV Watts)	Solar (NREL SAM Thermal)	Wind	Biomass
Capacity Factor		100%	100%	100%	88%	18-25%	15%	20%	92%
1	Tractor Port (1)		79			10		5	
2	CoolPV (27)	27	8			1	4		
3	Giraffe 2.0 (1)		79			14		0.40	
4	SmartFlower (1)		3			1			
5	Froling (1)	150							138
6	Arensis (1)	60	25						78
7	EGSB (1)	250							230
8	Smart Batteries		200		176				
9	Smart Street Light (50)		39			11		4	
10	CEE (50)		270	20	220				
11	Nuwe V2G (16)		960		845				
12	Nuwe VPP								
TOTAL kW per Hour		487	1,662	20	1,241	37	4	9	446
Annual Capacity in MWh		4,266	14,563	175	10,869	324	35	81	3,909
Total Annual MWh Capacity		**18,829**		**15,393**					

Source: National Renewable Energy Laboratory (NREL) System Advisory Model (SAM)

Biodico ZNEF

Biodico's ZNEF is located on a 1,300-acre parcel of Red Rock Ranch (RRR) in the San Joaquin Valley. The site is composed of a working farm which grows almonds, grapes, tomatoes, onions and garlic, and raises sheep. There is also an administrative office, cold storage facility, work-yard and biodiesel plant located on the site. RRR and the meter locations are shown below in Figure 30 as well as the meter service in kWh and the average use of each meter per month.

Figure 30: Zero Net Energy Farm at Red Rock Ranch



Account	Meter #	Meter Service in kWh	2015 Average Monthly Use in kWh		
			On Peak	Part Peak	Off Peak
1336831136-4	1008829078	30	177.77	465.10	963.63
3269674818-8	1461R8	628	851.89	1,120.00	4,575.14
4125193304-4	6PO129	30	277.65	447.15	2,193.15
	1003202413	45	373.55	1,040.40	3,491.40
	1009836617	30	339.84	586.22	2,488.42
8865086604-2	1009501838	261	9,056.95	25,490.86	56,745.87
	1009547191	89	374.43	1,067.88	3,392.78
	1009996304	37	377.57	421.53	2,366.90
Total Average Monthly Energy TOU			11,829.65	30,639.15	76,217.30
Total Average Annual Energy TOU			141,955.85	367,669.75	914,607.61
Total Average Hourly Energy TOU			16.21	41.97	104.41
Total Average Monthly Energy Use				118,686.10	
Total Average Annual Energy Use				1,424,233.21	
Total Average Hourly Energy Use				162.58	

This map shows the boundaries of the parcel site for ZNEF at Red Rock Ranch, and the location of power meters.

Source: 2017 Google Earth and Biodico

ESRI GeoPlanner was also used to create geo-referenced (Hackeloeer, Klasing, Krisp, & Meng, 2014)[5] interactive maps of the site, as well as to mark Key Performance Indicators (KPI) to analyze the resources and technology available for generating renewable energy, which can be seen in Figure 31. ESRI and Biodico worked together to create the ZNEF GeoPlanner that covers the entire state of California. By merely drawing the outline of any area in the state, the available resources and technology options will be shown. More detailed analysis can be done with the ZNEF GeoPlanner with the Optimizer function to balance the most effective technology for the available resources to meet energy demand and maximize revenues.

It is important to note that the ZNEF GeoPlanner is only available to licensed users and that due to the complexity of it, a potential user of the ZNEF GeoPlanner would need assistance from Biodico and ESRI to act as a facilitator, consultant and guide for using the ZNEF GeoPlanner.

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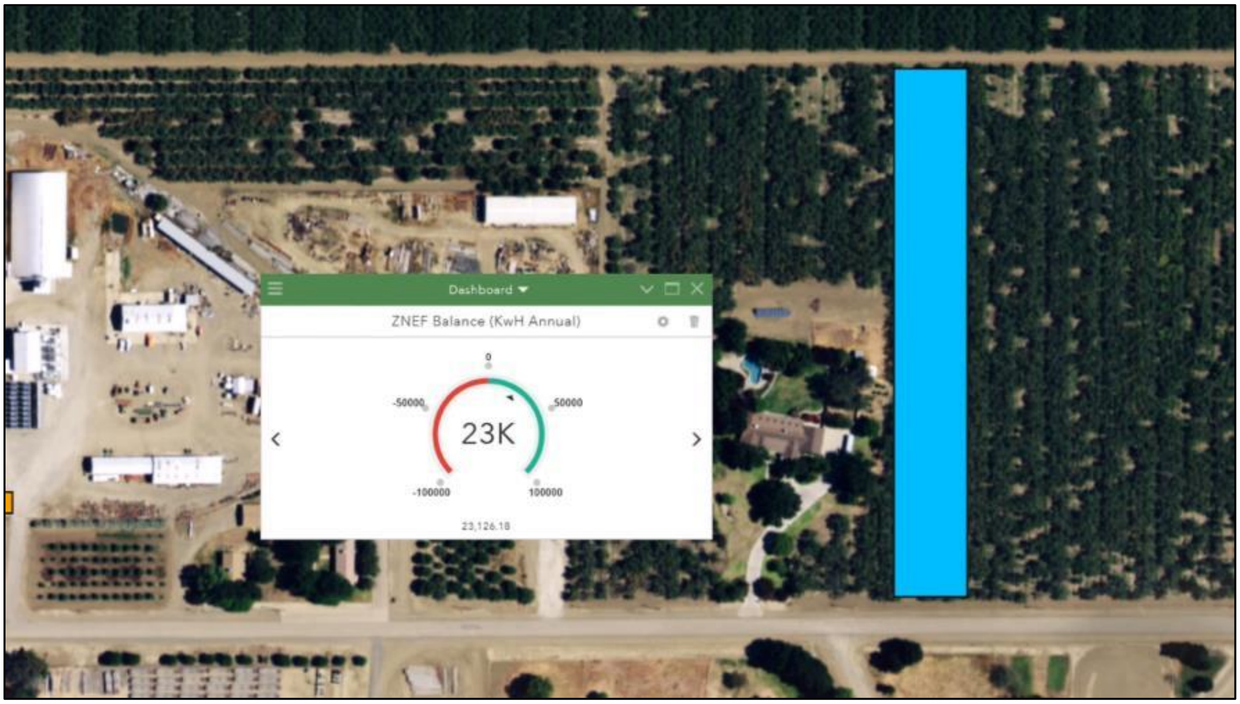
5 Georeferenced is commonly used in the Geographic Information Systems (GIS) field to describe the process of associating a physical map or raster image of a map with spatial locations. Hackeloeer, A.; Klasing, K.; Krisp, J.M.; Meng, L. (2014). "Georeferencing: a review of methods and applications". Annals of GIS. 20 (1): 61–69. doi:10.1080/19475683.2013.868826.

Figure 31: GeoPlanner detail with Key Performance Indicator



Source: 2017 ESRI and Biodico

CUP and CEQA

A Conditional Use Permit (CUP) and a CEQA Negative Declaration were issued for the proposed project sitewhich is shown in Figure 32. The lead agency was the Fresno County Planning Department (FCPD). They will be issuing the permits for construction associated with the ZNEF project and will be kept informed of the scope of the project. The San Joaquin Valley Air Pollution Control District (SJVAPCD) will also have jurisdiction over certain aspects of this project. Both FCPD and SJVAPCD are collaborators on the ZNEF grant and have been kept current about the status and scope of the proposed project.

Figure 32: Zero Net Energy Farm Distributed Energy Resource Site

Source: Google Earth and Biodico

Project Management Application

Biodico has developed and utilized a Project Management Application (PMA) with Geographic Information System (GIS) for the planning, permitting and financing of the ZNEF as a demonstration for agricultural and farmworker communities throughout California. It is called the ZNEF GeoPlanner and Optimizer.

The PMA was developed in consultation with ESRI (www.esri.com), the leading supplier of geographic information systems. A layered online map of California was developed which is accessible on the ZNEF website (www.zeronetenergyfarms.com). It includes the functionality shown in Figure 25 above and Table 4 below with embed applications that have been developed in Microsoft Excel Solver and Microsoft Project Manager.

The protocol for this process that utilizes the ZNEF GeoPlanner is to (1) identify the project site, (2) compile the resource assessment data (including solar, wind, biomass and environmental assessment factors), (3) match the resources with agriculturally appropriate technology to meet the energy needs of the site, (4) manage the permitting process, and (5) indicate the applicable financing mechanisms. See Appendices for details, *APPENDICES*.

ZNEF GeoPlanner

It is important to note that the ZNEF GeoPlanner is only available to licensed users and that due to Its complexity, a potential user of the ZNEF GeoPlanner would need assistance from Biodico and ESRI to act as a facilitator, consultant and guide for using the ZNEF GeoPlanner.

The base data maps for the PMA were used to determine the solar, wind and biomass resources present at the sites. Each of these is described in the KPIs for solar, wind, anaerobic digestion (AD) and gasification. The different types of renewable resources were then paired with agriculturally appropriate technology and sited on the GeoPlanner map.

It was also concluded that Westlands Water District[6] power is far less expensive than PG&E because the volume charges are low and there are no demand or TOU charges. Therefore, it was decided to keep the Westlands Water District meters and to use a Virtual Power Plant (VPP) to offset the power consumed and charges through a larger project on the remaining meters at the site. The results of the modeling are shown in *ZNEF Optimizer.*

ZNEF Optimizer

The Optimizer is embedded in the ZNEF GeoPlanner. Table 4 below shows an example of the ZNEF Optimizer applied to Red Rock Ranch, and illustrates two scenarios: (1) a smaller system optimized for the project area without the revenues from the VPP, and (2) a larger system optimized for the project area with revenues from the VPP. These scenarios show that a larger project can generate revenues and cover the costs of expanding the project.

6 Westlands Water District, http://wwd.ca.gov/, is a quasi-governmental special district that is the largest water district in the US. As a government agency, they have access to WAPA power, https://www.wapa.gov/About/Pages/about.aspx, that they use to pump ground water, canal water and irrigation water. They do not charge Red Rock Ranch for the electricity but include it in the cost of the water. The meters at Red Rock Ranch that are Westlands Water District owned are used for pumping water.

Table 3: Zero Net Energy Farm Optimizer

	A	B	C	D	E	F	G	H	I
2	Electric Power Technology	On Demand Power	Installed (kWh)	Capacity Factor	Installed x Capacity Factor (kWh)	Annual Power Potential (kWh)	Total OpEx & CapEx (20 years)	$/kWh (20 years)	Average $/kWh (20 Years)
3	Solar PV	☐	49.7	17.2%	8.5442	12,874	($124,190)	($0.083)	
4	Wind	☐	24.8	10.0%	2.4838	2,176	($31,047)	($0.071)	
5	Digester	☑	2.1	90.0%	1.9089	15,050	($74,234)	($0.222)	
6	Gasifier	☑	2.1	90.0%	1.9089	15,050	($74,234)	($0.222)	
7	Subtotal		79		14.8	90,297	($303,705)		($0.13)
8	Batteries	☑	5.1	82.0%	4.1902	30,099	($2,555)	($0.003)	
9	VPP	☑			0.0	0	$0		
10	Total Max $						($306,260)		
11	**Zero Net Energy Farm Optimizer**								
12	Electric Power Technology	On Demand Power	Installed (kWh)	Capacity Factor	Installed x Capacity Factor (kWh)	Annual Power Potential (kWh)	Total OpEx & CapEx (20 years)	$/kWh (20 years)	Average $/kWh (20 Years)
13	Solar PV	☐	70.0	17.2%	12	105,470	($175,000)	($0.083)	
14	Wind	☐	26.0	10.0%	3	22,776	($32,500)	($0.071)	
15	Digester	☑	25.0	90.0%	23	197,100	($875,000)	($0.222)	
16	Gasifier	☑	50.0	90.0%	45	394,200	($1,750,000)	($0.222)	
17	Subtotal		431		82	719,546	($2,832,500)		$0.04
18	Batteries	☑	260.0	82.0%	213	1,867,632	($390,000)	($0.010)	
19	VPP	☑			203	1,777,335	$5,459,000		
20	Total Max $						$2,236,500		
21	**Goals, Variables, Constraints & Result**								
22	Goal:	Optimize the cost of renewable energy types for ZNEF.							
23	By changing:	The Annual Power Potential (kWh) of each type of renewable energy.							
24	Constraint 1:	Total Annual Power Potential >= Historic Annual Electric Use (kWh)							90,297
25	Constraint 2:	Total On Demand Power >= Demand Charges plus Time of Use Shifting (kWh)							60,150
26	Constraint 3:	Average kWh <= kWh Capacity of Service Meter							100
27	Constraint 4:	Demand Charge kW<= kW Capacity of Service Meter							100
28	Constraint 5:	Batteries Annual Power Potential >= other Annual Power Potential combined							
29	Constraint 6:	Wind Installed Capacity <= 50% of SolarPV Installed Capacity (Tractor Port)							
30	Constraint 7:	VPP Annual Power Potential <= Annual Power Potential - Historic Annual Electric Us (kWh)							
31	Result:	20 year EBITDA for ZNEF Minimum and ZNEF Optimizer						($306,260)	$2,236,500

Source: 2017 Biodico

Rows 2-10: is the model for the Zero Net Energy Farm Minimum, which is limited by the Historic Annual Electric Use. It assumes that there will be no excess energy production for the Virtual Power Plant. SolarPV stands for Solar Photovoltaic and VPP stands for Virtual Power Plant, which is capable of automatically responding to dispatch requests from the California Independent System Operator (CAISO) of Investor Owned Utilities (IOU).

Rows 11-20: is the model for the Zero Net Energy Farm Optimizer, which is only limited by the amount of dollars and energy resources. It assumes that excess energy production will go to the VPP and that revenues will be generated as specified by the Storage Value Estimation Tool (StorageVET, http://www.storagevet.com/) as shown in APPENDIX N: StorageVET Readouts**Error! Reference source not found.**.

Rows 21-31: specifies the Goals, Variables, Constraints embedded in the spreadsheet and gives the Result of the model at Row 31.

Column A, for ZNEF Minimum and Optimizer: specifies the type of Electric Power Technology.

Column B, for ZNEF Minimum and Optimizer: indicates whether the type of technology is On Demand Power, which can be ramped up to power capacity within 15 minutes; otherwise the power is intermittent.

Column C, for ZNEF Minimum and Optimizer: is the Installed kWh of each Electric Power Technology.

Column D, for ZNEF Minimum and Optimizer: is the Capacity Factor, which is the percentage of the Installed Capacity that can be expected for each Electric Power Technology. Capacity Factors for SolarPV and Wind were determined by reference to the System Advisory Model by the National Renewable Energy Laboratory (https://sam.nrel.gov/), and for Digesters, Gasifiers and Batteries by reference to the manufacturers.

Column E, for ZNEF Minimum and Optimizer: is the Installed Capacity multiplied by the Capacity Factor. The results are given in kWh.

Column F, for ZNEF Minimum and Optimizer: is the Annual Power Potential which is Column E (hourly) multiplied by 24 (hours per day) multiplied by 365 (days per year) to give the kWh per year.

Column G, for ZNEF Minimum and Optimizer: is the Total OpEx (Operating Expenditures) and CapEx (Capital Expenditures) for each Electric Power Technology over a 20-year period.

Column H, for ZNEF Minimum and Optimizer: is Column G divided by Column F (multiplied by 20 years) to give the cost per kWh.

Column I. for ZNEF Minimum and Optimizer: is the Average Dollars per kWh over twenty years, which is a cost of $.13 per kWh for the ZNEF Minimum and profit of $.04 for the ZNEF Optimizer.

Row 31 is the Result, given as Earnings Before Interest Taxes Depreciation and Amortization (EBITDA), which for the ZNEF Minimum is -$306,260, and for the ZNEF Optimizer is $2,236,500.

Request for Proposal

Goals of the Request for Proposal

In preparation for submitting an application to the Phase II award of the Advanced Energy Communities solicitation, the project team issued a Request for Proposal (RFP) with the following statement of goals: "The Project Team of Correlate Inc, Biodico, Inc, and Red Rock Ranch, Inc.; are pursuing a Zero Net Energy Farm as part of an already-awarded California Energy Commission Grant for planning. The overall project will (1) pilot innovative planning, permitting and financing approaches to improve the business case for Advanced Energy Communities (AEC) using Net Energy Meter Aggregation (NEMA) to achieve Zero Net Energy Farms (ZNEF), and (2) develop a real world conceptual design for a ZNEF that includes technical and engineering considerations in a Master Community Design (MCD). Phase 2 of the grant will be awarded at the discretion of the Energy Commission and will involve the implementation of the planned project."

Contents of the RFP

A Request for Proposals (RFP) was prepared by Biodico with assistance from subcontractor Correlate and was released on August 16, 2017 with responses due September 6, 2017. The RFP was for the DER technologies, listed on Table 5, to be installed at the ZNEF site as described in *APPENDIX M: Request for Proposals.* These include:

- Description of Desired Solar System: Canopy systems and Tractor Ports are the desired structure for the Work Yard, so that farm equipment and materials can still be stored. Optional Fafco CoolPV to be installed as an awning on south side of Biodico building.
- Smart Batteries: a minimum of 190 kWh of energy storage capacity stall be provided, capable of peak demand and time of use shaving. To be installed on southwest corner of Biodico building.
- Integration: All elements in Table 4 above not in blue to be integrated into NEM system. (See scope section 4)
- Two meters: to be reduced to one meter for NEM.
- Project Financing: Cash Purchase.
- System Ownership Information: Biodico, Inc. with grant funding from the CA Energy Commission.
- Operation & Maintenance: Respondents are required to include proposals for 5, 10, and 20-year O&M plans for the entire solar electric system. Please include O&M costs as a separate line item for a cash purchased system. Further details are in the O&M section of this RFP.
- Monitoring: Install a weather station (temperature, humidity, wind speed and direction, rainfall, and solar insolence) and web display kiosk providing project information should be included.
- Warranty and Performance Bond – OEM warranties shall be described and only "bankable" and not potentially impacted by any pending international trade petitions equipment from companies expected to be in business for 20 years will be considered.

Table 4: Distributed Energy Resources Technologies included in the RFP

		Watts/Electric	Watts/Heat	btu/Heat
1	Tractor Port			
	Solar PV	50,000		0
	Wind Turbines (12 two kW each)	24,000		0
2	Fafco CoolPV	6,600	24,000	81,840
3	Smart Flower	2,500		0
4	InnoVentum Giraffe 2.0 (solar/wind EV charger)	10,200		
5	Solar Eind Street Lamp (12)	6,000		0
6	Anaerobic Digester		150,000	511,500
7	Gasifier			0
	Froling T4-150		150,000	511,500
	Entrade E4	50,000	120,000	409,200
8	Smart Batteries	190,000		0
9	EV V2G	24,000		0
	TOTALS	**363,300**	**444,000**	**1,514,040**

Blue	Not to be integrated as part of RFP
Pink	To be installed by Biodico, but integrated by respondent
Orange	To be installed & integrated by respondent

Source: 2017 Biodico

RFP Award

Responses to the RFP were received and reviewed by Biodico, Correlate and Red Rock Ranch. The project team decided to award the RFP to a consortium of Borga Steel and Shorebreak Energy Developers (Borga/Shorebreak). The Borga/Shorebreak proposal was responsive to every criterion in the RFP, they were the best qualified, and their price was the best. The project team is now in a good position to begin execution of the Master Community Design should it be awarded the Phase II grant from the Energy Commission.

Permitting

The County of Fresno operated as the lead CEQA agency with regard for the Conditional Use Permits (CUP) for this project. CUP number 3366 was approved by the Fresno County Planning Commission on September 13th, 2012. This approval authorized a facility dedicated to the conversion of sugar beets into biofuel (ethanol) and biodiesel, and it also recognized an unpermitted oilseed production facility that would provide oil for the biodiesel production component of the operation. The biofuel (ethanol), biodiesel, and oilseed production facilities would all be located on a 14.39-acre parcel contained within Red Rock Ranch. The rest of the ranch, a southerly-adjacent 39.27-acre parcel, would be utilized to provide an administrative office and parking lot for the production facilities.

After this CUP approval, Biodico requested that County staff make a determination as to whether a solar cogeneration system, anaerobic digesters, and gasification cogeneration systems would also be allowed at the Red Rock Rach site to use in conjunction with the biofuel (ethanol), biodiesel, and oilseed production facilities. County staff responded to this request on

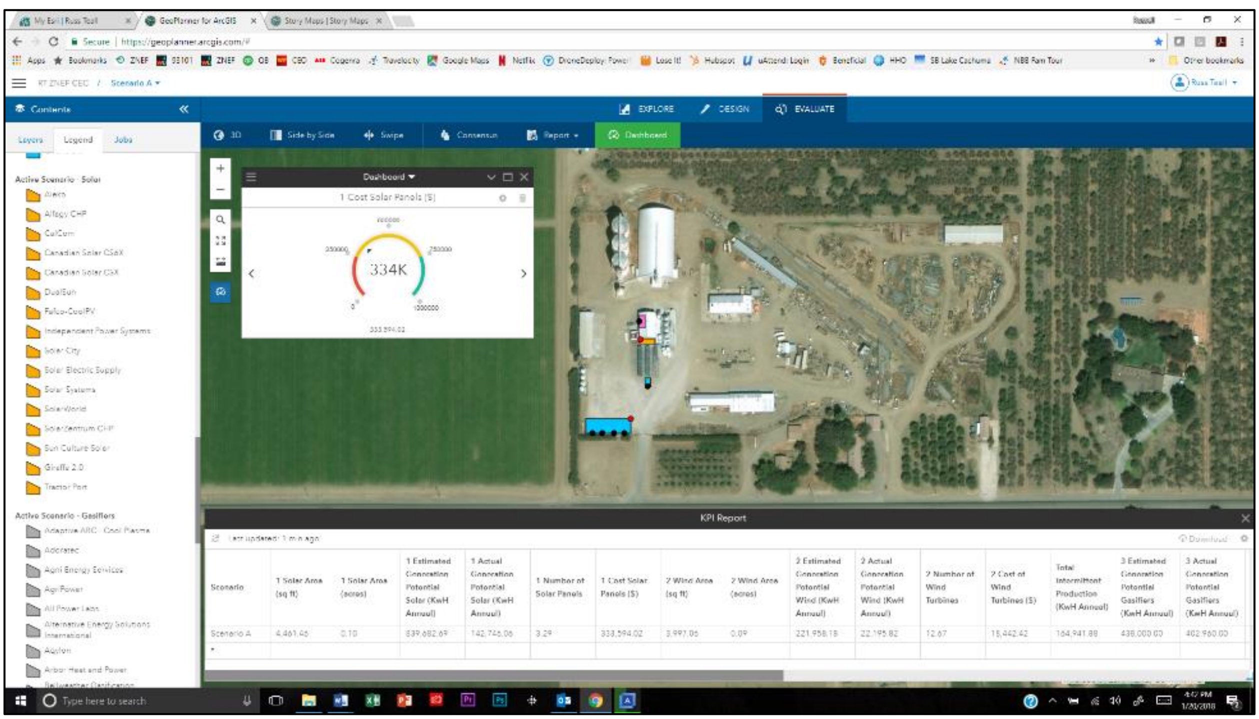
March 13th, 2013, stating that these additions would be in compliance with the CEQA analysis prepared for the previous CUP (number 3366).

A second CUP (number 3462) was approved by the Fresno County Planning Commission on September 18Th, 2014. This CUP authorized an amendment to the first CUP (number 3366) regarding the re-location of the biofuel (ethanol) production facility from the original 14.39-acre parcel to the southerly-adjacent 39.27-acre parcel previously designated for the administrative offices. The amendment also modified the planned location of the tanks used for biodiesel production to a proposed concrete foundation on the 14.39-acre parcel, rather than inside an existing structure on the parcel, as was stated in the initial CUP.

Financing

The ZNEF GeoPlanner can help determine the cost of a project based on the type of optimal DERs for a given location. Screen shots of the Program Manager developed for ZNEF are shown below in Figure 33. After the resource assessment and agriculturally appropriate technology have been determined, permitting and financing can begin. Prior to finalizing financing, permitting has to be completed and in many cases the project has to completed and operating before certain incentives, subsidies and tax credits can be applied. Financing programs can be generic or more specific depending upon the type of renewable energy technology.

Figure 33: Screenshot of GeoPlanner Report



Source: 2018 Biodico and ESRI

The proposed project is also expected to qualify for multiple state and federal incentives. The primary incentives for this project are the Self-Generation Incentive Program (SGIP), the Business Energy Investment Tax Credit (ITC), and the Renewable Energy for America Program

(REAP). Table 6 below describes each of the funding mechanisms available for the individual ZNEF Components. Overall there are over $2,400,000 of incentives available, and over $3.6 million in loan guarantees.

Table 6: Funding for Zero Net Energy Farms Components

Program	SGIP						BEITC		REAP		
Incentives & Loan Guarantees	Wind per watt	CHP w/Biogas Adder per watt	Large Energy Storage per Wh	Large Energy Storage w/ITC per Wh	Residential per Wh	Non-Residential Equity per Wh	Solar & Small Wind	CHP	Renewable Energy System Max $500,000	Energy Efficiency Max $250,000	Guaranteed Loan Max $25 million
Amount	$ 0.90	$ 1.20	$ 0.50	$ 0.36	$ 0.50	$ 0.35	30%	10%	25%	25%	85%
Tractor Port	21,600						108,000		90,000		
CoolPV							72,000		60,000		
Giraffe 2.0	1,800						45,000		37,500		
SmartFlower							10,500		8,750		
Froling		180,000						12,500	31,250		
Arensis		102,000						75,587	188,968		
EGSB		300,000						50,000	125,000		
Smart Batteries			100,000								
Smart Street Light	45,000						30,000				
CEE					62,500	47,250				62,500	
Nuwe V2G				345,600			193,500				
Total per Category	68,400	582,000	100,000	345,600	62,500	47,250	459,000	138,087	541,468	62,500	3,609,346
Total per Incentive	$1,205,750						$597,087		$603,968		
Total	$2,406,805										$3,609,346

Source: 2017 Biodico

Table 7 shows how the incentives work into the overall financial strategy for the project. The total budget for the ZNEF project is $15,344,174, composed of $9,224,245 in match and $6,119,929 in Energy Commission funding, which the project team will compete for as part of the Phase II Advanced Energy Community solicitation. Incentives to be garnered over the life of the project are $2,406,805 coupled with a government guaranteed loan of $4,246,290.

Table 7: Budget Breakdown

Total Budget*			$ 15,344,174
	CapEx	$ 5,307,862	
	OpEx	$ 10,036,312	
Match Funding			$ 9,224,245
	Biodico	$ 2,878,426	
	Vendors	$ 3,641,358	
	Net Energy Savings	$ 2,351,661	
	VPP Revenue	$ 352,800	
CEC Funding			$ 6,119,929
Incentives (to Biodico)			$ 2,406,805
	SGIP	$ 1,205,750	
	ITC	$ 597,087	
	REAP	$ 603,968	
Loans	80% of CapEx		$ 4,246,290
	REAP Loan Guarantee 85% of Loan		$ 3,609,346

Source: 2017 Biodico

Pro Formas

A pro forma financial statement was prepared in advance of the proposed project and models the anticipated results, with an emphasis on the projected capital expenditures (CapEx), operating expenditures (OpEx) and revenues/savings. It is presented in Table 8 Lenders and investors require such statements to structure or confirm compliance with debt covenants such as debt service reserve coverage and debt to equity ratios, coupled with a cash flow analysis. (Ross & Wasterfield, 2008).[7]

[7] Ross, Stephen; Wasterfield, Randolph W. (2008). Corporate Finance. The McGraw-Hill. p. 64. ISBN 0-07-310590-2.

Cash Flow Proforma for the Current Project

$ in thousands

Item	Year	2019				2020				2021				2022				2023				2024		Total
	Quarter	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	
	Total																							
Carryover		25	10	27	153	279	405	530	656	782	3,499	3,449	3,399	4,250	4,200	4,151	4,101	4,952	4,902	4,852	4,802	5,654	5,861	
Expense	(15,612)	(412)	(1,026)	(1,026)	(1,026)	(1,026)	(1,026)	(1,026)	(1,026)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(667)	(13)	0	(15,612)
Direct Labor	(3,798)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)	(190)			(3,798)
Fringe	(380)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)			(380)
Equipment	(2,516)		(359)	(359)	(359)	(359)	(359)	(359)	(359)															(2,516)
Miscellaneous	(2,929)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)	(146)			(2,929)
Subcontractors	(4,592)		(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)			(4,592)
Indirect Costs	(1,129)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)			(1,129)
Loan Payments	(268)		(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)		(268)
CEC	6,120	0	220	579	579	579	579	579	579	579	220	220	220	220	220	220	220	220	220	220	220	220	489	7,405
Direct Labor	1,899		85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	190	1,899
Fringe	190		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	19	190
Equipment	1,231			359	359	359	359	359	359	359														2,516
Miscellaneous	0																							0
Subcontractors	2,235		101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	224	2,235
Indirect Costs	564		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	56	564
Match	9,171	397	573	573	573	573	573	573	573	397	397	397	397	397	397	397	397	397	397	397	397	0	0	9,171
Direct Labor	1,899	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95			1,899
Fringe	190	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9			190
Equipment	1,231		176	176	176	176	176	176	176															1,231
Miscellaneous	2,929	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146			2,929
Subcontractors	2,357	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118			2,357
Indirect Costs	564	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28			564
Income	5,361	0	250	0	0	0	0	0	0	2,407	0	0	901	0	0	0	901	0	0	0	901	0	0	5,361
Revenue	2,704												901				901				901			2,704
Incentives	2,407									2,407														2,407
Loan	250		250																					250
Total	5,040	10	27	153	279	405	530	656	782	3,499	3,449	3,399	4,250	4,200	4,151	4,101	4,952	4,902	4,852	4,802	5,654	5,861	6,349	

Table 8: Cash Flow Pro Formas

Financing Mechanisms

Financing programs can be generic to a particular project or specific to the type of renewable energy technology being used. Table 9 lists the different entities offering finance for ZNEF-like projects and the programs they offer.

Table 9: Financing Mechanisms

Financing Mechanisms	
Agency or Entity	**Program**
Rural Community Assistance	
CA Air Resources Board	Cap & Trade, LCFS & Grants
CA Department of Food & Agriculture	Grants for Digesters & Gasifiers
CA Energy Commission	EPIC & ARFVTP Grants
CA Recycle	Grants for Digesters & Gasifiers
CA Governor's Office	iBank, Industrial Develpment Bonds, Small Business Loan Guarantees, GoBiz Tax Incentives, CA Competes Tax Credit, Partial Sales & Use Tax Exemption, New Employment Tax Credit, Employment Training Progrm, New Employment Opportunity (NEO)
CA Public Utilities Commission	Self Generation Incentive Program, Demand Response
CA Treasurer's Office,	Sales Tax Exclusion, California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA), Qualified Energy Conservation Bonds, Property Assessed Clean Energy (PACE)
Cities & Counties	Regional Solar Choice, Community Choice
Loans	Conventional Project Financing, Government Loan Guarantee Support Programs
PG&E	Enhanced Community Renewables (ECR) Program, NEM/NEMA, Power Purchase Agreements, Solar Venicles Electric Use Incentives
Private Equity	Impact Investing, Socially Responsible Investing (SRI), Environmental, Social & Governance(ESG), Principals for Responsible Investment (PRI), Ventura Capital, Family Offices, High Net Worth Individuals, Instituional Investers, Strategic Joint Ventures, New Market Tax Credits, Smal Business Investment Company
US Department of Agriculture	Grants & Loans for Rural Development, Renewable Energy and Biomass
US Department of Energy	Grants & Loans for Renewable Energy
US ExIm Bank	Credit Guarantees for Foreign Buyers, Cash Flow Financing, Loan Guarantees, Environmental Export Program
US Internal Revenue Service	Investment Tax Credit, Renewable Power Standard, Industrial Development Bonds, Made in America Tax Credit, New Market Tax Credits, EB-5 Program
US Small Business Administration	Small Business Investment Company, Small Business Loans

Source: 2017 Biodico

CHAPTER 4: Technology/Knowledge Transfer

The proposed project will benefit a broad range of parties, including IOUs and California ISO , agricultural interests, farmworker communities, general public, media, academia, regulators and politicians. Designing an effective outreach campaign needs to combine multiple elements to reach these diverse interests, shown in Figure 34. One factor unites these groups: Fresno County has some of the worst air quality in the US. Most stakeholders are clearly behind the adoption of solutions that address this problem. The salient questions are cost, ease of implementation, and effectiveness. As shown by the involvement of diverse team members, the community has already embraced the concept of the ZNEF.

Figure 34: Diagram of the Outreach Campaign

Source: Creative Commons and Biodico

To achieve the greatest impact for the outreach campaign, Biodico included as team members: (1) a professional public relation firm (PondelWilkinson), (2) a "commercial film quality" videographer (18Thirty Entertainment), (3) a community art director (Anne Whitehurst), and (4) the leading ArcGIS company in the world (ESRI). Their objective was to generate exposure for this project by producing informative materials in multiple formats to maximize engagement, as well as to ensure the content resonates with key audiences. Biodico worked with these team members to create informative and compelling media material and implement an effective dissemination strategy including community input, fact sheets, press releases, media interviews, media alerts, press releases, an annual video documentary, community art engagement events, interactive maps, blogging, internet and social media, workshops, conferences, and event-driven media opportunities as part of the outreach campaign.

A project website was created to share information about the ZNEF project, as well as provide interested users, a way to access the ZNEF GeoPlanner Tool. The project website is available at: http://www.zeronetenergyfarms.com/

The website also features a promotional video that was produced to share with stakeholders the concept of the ZNEF. The video can be viewed here: https://www.youtube.com/watch?v=za3bbyol27g&t=1s

ZNEF Summit

The project team held a ZNEF Reception and Summit on November 2-3, 2017 and was attended by over one hundred participants representing local business leaders, farmers, farmworkers, academics, and local governments. The objective of the ZNEF Summit was to present the MCD to interested stakeholders, incorporate their feedback, and engage in discussion about the issues surrounding the ZNEF project. Some of these issues include the future of renewable energy technologies, economic development and environmental impacts.

A consistent graphic theme, shown in Figure 35, was employed for all collateral material created for the event, including email invitations, EventBrite reservation web site, notices, Summit Agenda, press release, articles and an Op-Ed piece that ran in the Fresno Bee.[8]

[8] https://www.fresnobee.com/opinion/readers-opinion/article183329801.html

Figure 35: Zero Net Energy Farm Summit Graphic

Source: 2017 Biodico

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CHAPTER 5: Project Benefits

The benefits of the Zero Net Energy Farm project are that it (1) is highly replicable within California's agricultural community, (2) increases the efficiency, resiliency and reliability of the grid, (3) enhances energy security by distributing and localizing energy production, (3) mitigates the adverse environmental impacts of producing conventional electricity by (i) decreasing water consumption, (ii) mitigating emissions of greenhouse gases, criteria air pollutants and air toxins, and (iii) reducing adverse impacts to human health , and (4) stimulates green job creation and economic development in one of the most disadvantaged areas of California. Roughly $15 billion is spent overall on electricity for California agriculture and 288,000,000 megatons of CO_2 are released in California statewide. The first Zero Net Energy Farm project will have many projected benefits related to these two areas. It will save roughly $800,000 in electricity per year for the 1,300 acres of farming and mitigate roughly 4,000 megatons of CO_2 equivalent emissions annually. Additionally, the first Zero Net Energy Farm project will save over one thousand acre feet of water and shift roughly 15,000 MWh from peak load times per year. This translates to both cost savings for the farmers themselves and environmental benefits for California as a whole.

Replicability is a primary benefit of this pioneering project. Table 9 below is a preliminary calculation for the project and expansion to other agricultural areas. The potential for expansion is derived from the ratio of the acreage for this project to the total cultivated agricultural acreage in California, the US and the world. Assuming 1 percent penetration, the potential quantitative benefits are shown in Table 10.

Table 10: Replicability Potential of this Master Community Design

Item	ZNEF	CA Ag	US Ag	World Ag
Acres	1,300	25,000,000	915,000,000	3,706,575,000
Ratio	1	19,231	703,846	2,851,212
1% Market Penetration		192	7,038	28,512
MWh/Year	15,393	2,960,127	108,340,654	438,877,331
Annual Cost Savings	$783,887	$150,747,553	$5,517,360,457	$22,350,284,519
Line Loss Recovery (MWh)	831	159,847	5,850,395	23,699,376
Water Reduction (acre ft)	1,181	227,102	8,311,915	33,670,752
TOU Shifting (MWh)	15,392	2,960,043	108,337,561	438,864,804
NOx Reductions (MT)	-7.45	-1,432	-52,424	-212,363
GHG Reductions (MT)	-4,356.12	-837,716	-30,660,405	-124,202,285
Full-time Jobs	18	3,462	126,692	513,218

Source: 2017 Biodico

Additionally, these renewable generation technologies produce usable energy as soon as they are installed, meaning the myriad of benefits will be realized almost immediately. The one exception being AD, which once installed requires 30 days for the methanogens to process the material.

Aside from electric ratepayers, feedstock suppliers, as well as many market segments, will be impacted by the project. Material that is usually discarded on feedstocks such as pruning material and solid biomass can now be put to use generating energy, thus positively impacting the agricultural market. AD convert waste products from other biomass refineries, trap grease from restaurants, and liquid and slurry waste products from surrounding agricultural and biomass production facilities. Under the assumption that farmers may aggregate electricity generated onsite and have those rates on hand, the agricultural industry would be greatly impacted by the project. The project will also impact the market for installation, service and operational professionals. Impacted markets are:

- Feedstock providers of woody ag waste
- Feedstock providers of manure (1,800 dairies in CA with over 1,800,000 milking cows)
- Manufacturers of distributed renewable equipment (solar cogen, wind turbines, AD and gasifiers) all of which are manufactured in California.
- Farms, dairies and ranches (reduced utility cost)
- Other agricultural interests (food processors reduced utility cost)
- Consumers (reduced food cost because farmer and processors cost of goods sold is less)
- Labor (increased installation work for the building trades)
- Water market (decreased water consumption for the production of electricity)
- Medical services market (decreased health impacts from lower toxic/criteria air pollutants)

The project will provide numerous community benefits as well. The site is in a disadvantaged community with an unemployment rate of 14.5 percent. Many of the DER components in the microgrid will be installed and maintained by locals, specifically trained for this project. These workers will thus not only be employed through this project, but will move forward with highly marketable skills in a growing industry. The local economy will be further supported by the need for material suppliers, contractors, and other services which create secondary businesses. Excitement and boosted morale from the introduction of a new industry in rural, underappreciated communities will be an additional intangible benefit.

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CHAPTER 6: Recommendations, Conclusions and Next Steps

Recommendations

The recommendations based on compiling this Master Community Design are:

1. Net Energy Metering Aggregation tariffs should be increased to encourage distributed renewable energy production in excess of energy needed to offset retail rates.
2. A low interest revolving loan fund should be set up by the State of California to encourage distributed renewable energy projects.
3. The Master Community Design should be expanded to include farmworker communities.
4. The Virtual Power Plant relationship and tariffs with California ISO /IOU should be further developed.

Conclusion and Next Steps

The conclusions based on compiling this Master Community Design are:

1. Agricultural distributed renewable energy production is feasible based on the resources and technology available.
2. Technology for using on-site renewable resources can be made agriculturally appropriate.
3. The ZNEF GeoPlanner is a web-based tool that utilizes solar, wind, and biomass data, with DER technology product specific specifications, in order to integrate renewable energy into IOU electric grids by estimating location-specific energy generation for distributed energy resources. The ZNEF GeoPlanner is used to identify the planning, permitting, and financing requirements for a ZNEF, which fast tracks the implementation process and eases the financial burden on investors.

The next steps are:

1. Construct and operate the Master Community Design. Initial steps in this process included assessing the available resources at the proposed site and using the ZNEF GeoPlanner to carefully select the optimal DER technologies. Next, the permitting process will continue through the Fresno County Planning Department as needed, and financing estimates and outreach will allow for more precise budgeting and ZNEF construction. Once constructed, the operation and construction process can be used as a template for future projects.
2. Continue updating the databases and functionality of the ZNEF GeoPlanner and Optimizer. As more data is gathered, the ZNEF GeoPlanner will be updated, ensuring

accuracy and efficacy as conditions change year to year. Additional changes will be made to further improve the platform's usability.

3. Conduct an outreach campaign to inform other agricultural interests of the potential for ZNEFs in other areas. This campaign will employ various promotional strategies to encourage ZNEF adoption throughout the agricultural industry, highlighting both the industrial economic benefits and the public health improvements of ZNEF implementation.

GLOSSARY

Term	Definition
Distributed Energy Resources	Distributed energy resources (DER) are defined as distribution-connected distributed generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies
EPIC (Electric Program Investment Charge)	The Electric Program Investment Charge, created by the California Public Utilities Commission in December 2011, supports investments in clean energy technologies that benefit electricity ratepayers of Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company.
Green Raitero Independent Transportation	A community ride sharing program based upon a Mexican tradition but using green vehicles and fuel.
microgrid	A group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. Additionally, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. Finally, microgrids can also manage customer critical
smart batteries	Smart battery energy Storage can supply more flexibility and balancing to the grid, providing a back-up to intermittent renewable energy. Locally, it can improve the management of distribution networks, reducing costs and improving efficiency. In this way, it can ease the market introduction of renewables, accelerate the decarbonization of the electricity grid, improve the security and efficiency of electricity transmission and distribution, stabilize market prices for electricity, while also ensuring a higher security of energy supply. Examples are the Tesla PowerWall and PowerPack.
smart grid	Smart grid is the thoughtful integration of intelligent technologies and innovative services that produce a more efficient, sustainable, economic, and secure electrical supply for California communities.
Smart Lamp / Smart Farm	Smart Lamp and Smart Farm are part of the Master Community Design described in this paper.
Vehicle-to-Grid	Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEV), plug-in hybrids (PHEV) or hydrogen Fuel Cell Electric Vehicles (FCEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate. Vehicle-to-grid can be used with

	gridable vehicles, that is, plug-in electric vehicles (BEV and PHEV), with grid capacity. Since at any given time 95 percent of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back.
Virtual Power Plant	A virtual power plant (VPP) is a cloud-based distributed power plant that aggregates the capacities of Distributed Energy Resources (DERs) for the purposes of enhancing power generation, as well as trading or selling power on the open market. It combines the power generated from many DERs into a single combine pool of generated power.
Zero Net Energy Farm	Zero Net Energy Farms (ZNEF) generate all of their own fuel & power from on-site renewable resources, while reducing greenhouse gases and providing meaningful jobs and economic development

ACRONYMS

Acronym	Full Designation
AD	anaerobic digester
CAISO or Cal-ISO	California Independent System Operator
CALEPA	California Environmental Protection Agency
CapEx	capital expenditures
CARB	California Air Resources Boards
CCA	Community Choice Aggregation
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CES	Customized Energy Solutions
CHP	combined heat and power
CUP	Conditional Use Permit
DER	distributed energy resources
DERA	distributed energy resource aggregation
DERP	distributed energy resource provider
DERPA	distributed energy resource provider agreement
DRAM	demand response auction mechanism
EGSB	expanded granular sludge bed digester
EIT	Engineer in Training, precursor to PE
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ESRI	Earth Science Research Institute
ExIm	Export Import Bank of the United States
EV	electric vehicle
GHG	greenhouse gases

Acronym	Full Designation
GIS	Geographic Information System
GRIT	Green Raiteros Independent Transportation
IOU	Investor Owned Utility
IPMVP	International Performance Measurement and Verification Protocol
JD	Juris Doctor
KPI	key performance indicator
LRA	local regulatory authority
MCD	Master Community Design
MSASC	meter service agreement for scheduling coordinators
MSS	metered sub system
NAP	Nuvve Aggregation Platform
NMEC	Normalized Metered Energy Consumption
NREL	National Renewable Energy Laboratory
OpEx	operating expenditures
PG&E	Pacific Gas and Electric
PE	licensed professional engineer
PJM	Pennsylvania, New Jersey and Maryland
PMA	Project Management Application (also called the ZNEF GeoPlanner)
PV	photovoltaic
RFP	request for proposals
SBA	Small Business Administration
SBIC	Small Business Investment Corporation
SC	scheduling coordinator
SCME	Scheduling coordinator metered entities
SQMD	settlement quality meter data
StorageVET	storage value estimation tool
USDA	United States Department of Agriculture

Acronym	Full Designation
USDOC	United States Department of Commerce
USDOE	United States Department of Energy
UDC	utility distribution company
V2G	vehicle to grid
VPP	virtual power plant
WRT or wrt	with respect to
ZNEF	Zero Net Energy Farm

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APPENDICES

The following appendices can be found in the Final Report Appendices published as a separate report CEC-500-2019-045-APA-R.

APPENDIX A: Tractor Port

APPENDIX B: CoolPV

APPENDIX C: Giraffe 2.0

APPENDIX D: SmartFlowers

APPENDIX E: Froling T4 Wood Chip Boiler

APPENDIX F: Entrade E3-E4 Gasifier

APPENDIX G: Expanded Granule Sludge Bed Anaerobic Digestion

APPENDIX H: Smart Batteries

APPENDIX I: Smart Lamp / Smart Farm

APPENDIX J: Community Energy Efficiency

APPENDIX K: Nuvve Vehicle to Grid

APPENDIX L: Nuvve Aggregation Platform

APPENDIX M: Request for Proposals

APPENDIX N: StorageVET Readouts

APPENDIX O: Cost of Power Outages

APPENDIX P: RIMs II Modeling

APPENDIX Q: Project Management Application Report

APPENDIX R: Technical Advisory Committee Comments